TAB J
PART 9

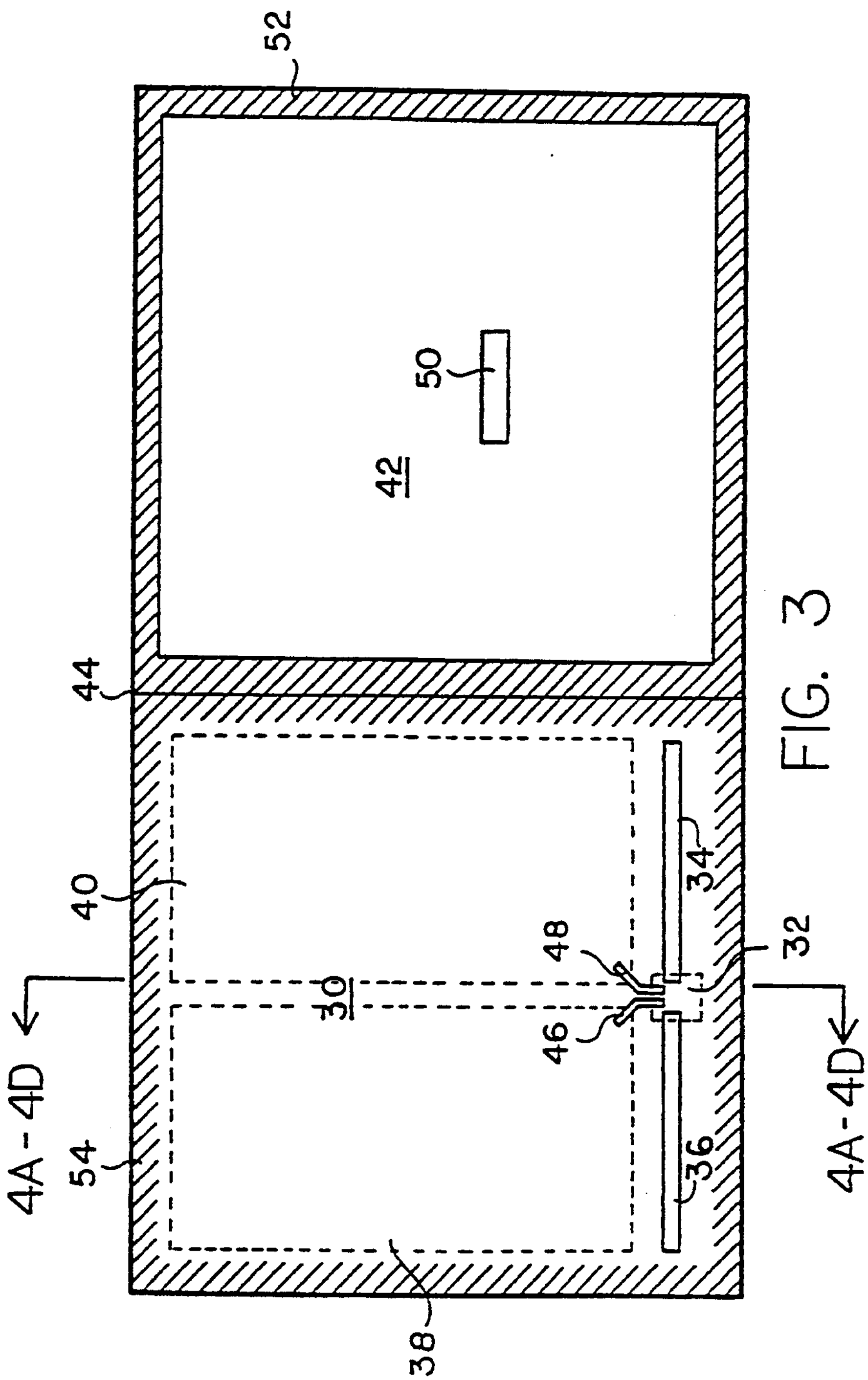


FIG. 3

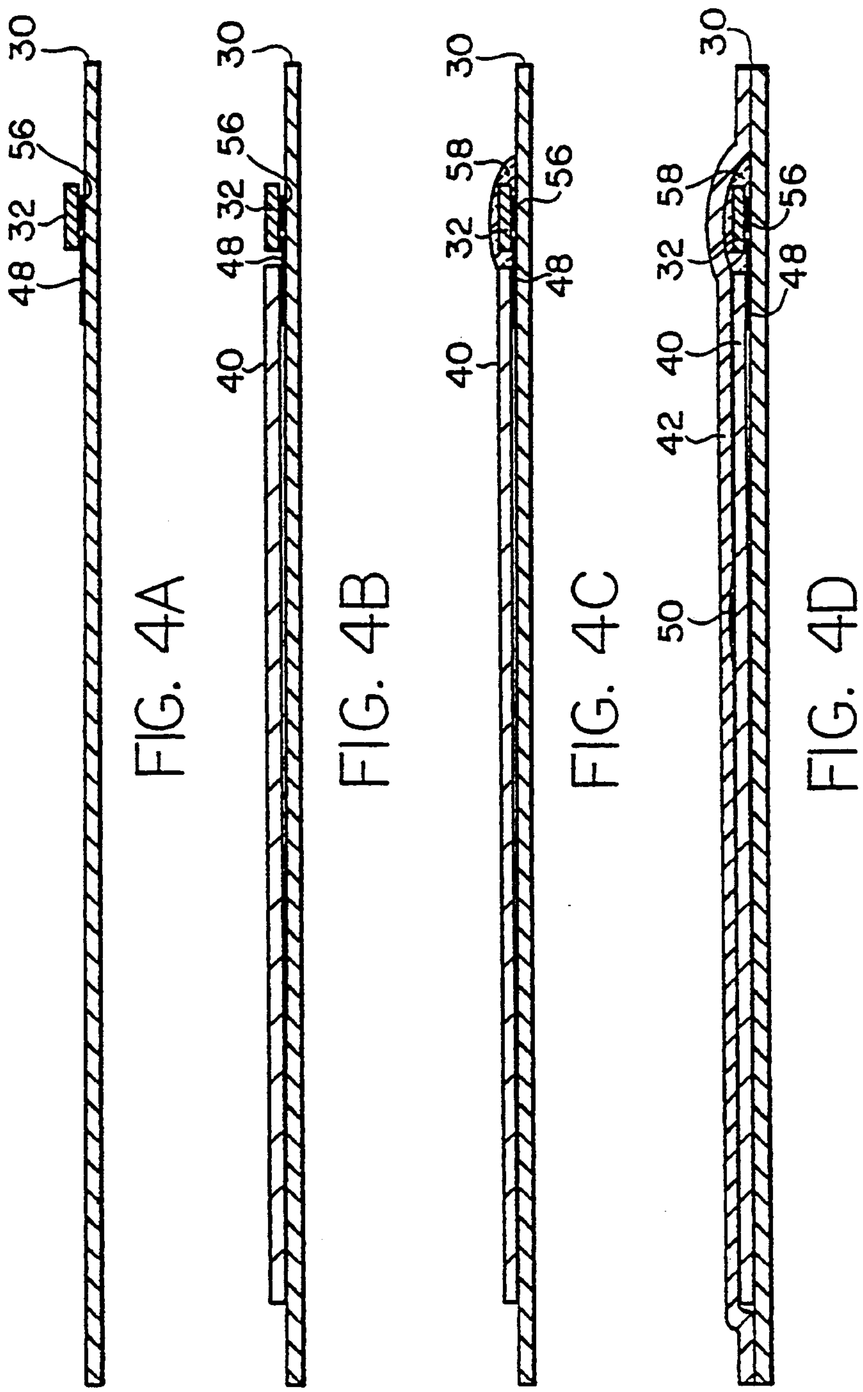


FIG. 4A

FIG. 4B

FIG. 4C

FIG. 4D

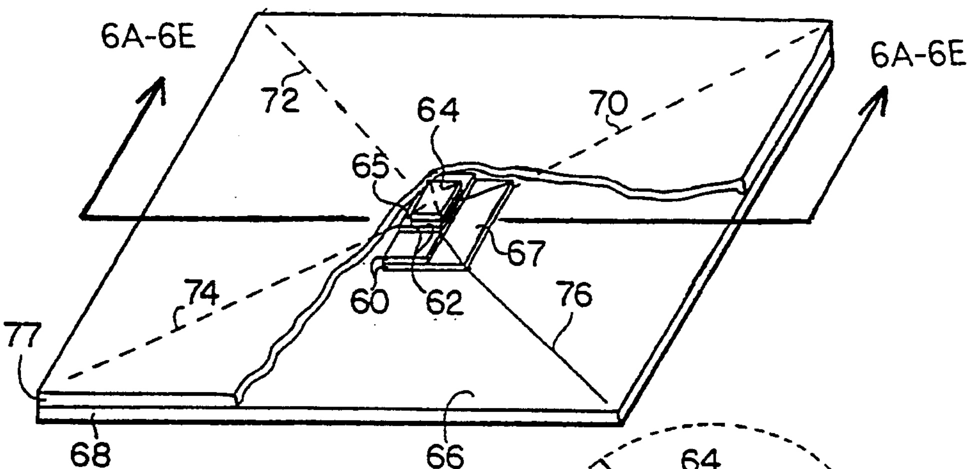


FIG. 5A

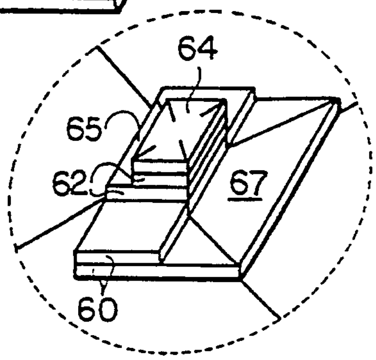


FIG. 5B

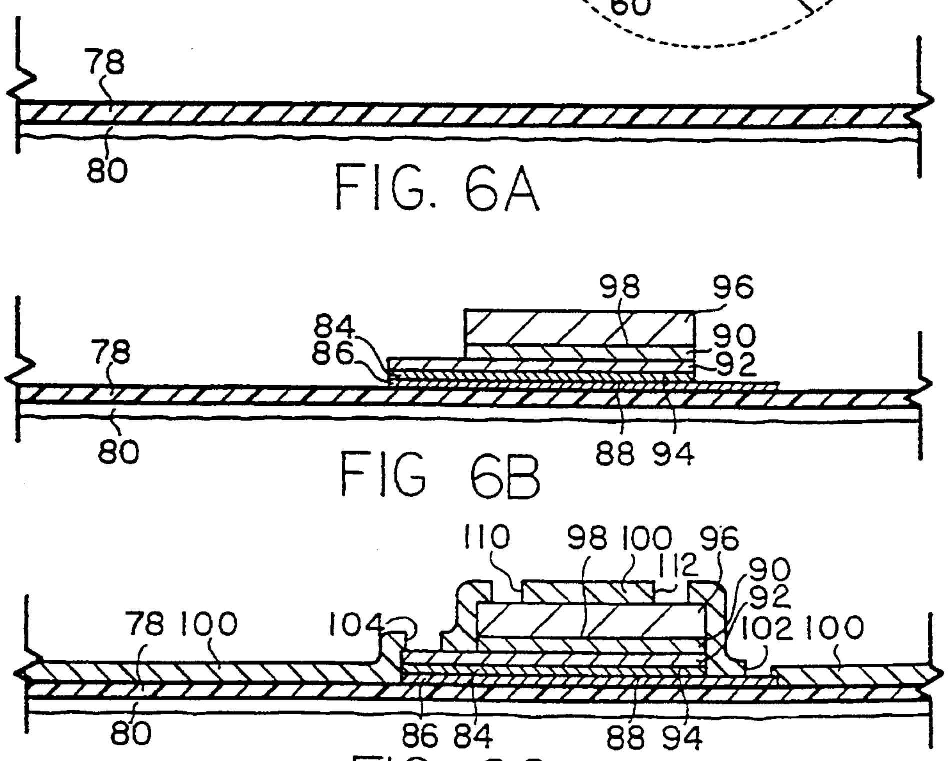


FIG. 6A

FIG 6B

FIG. 6C

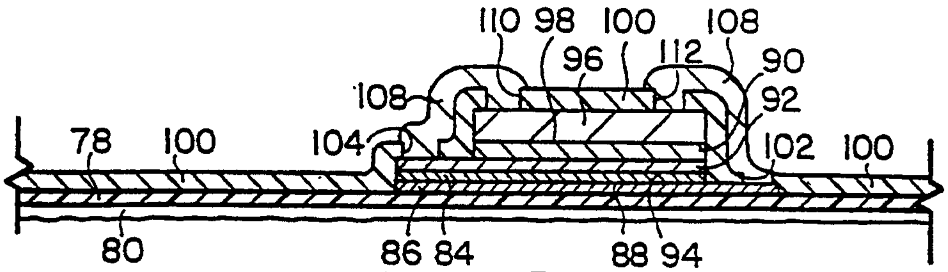


FIG. 6D

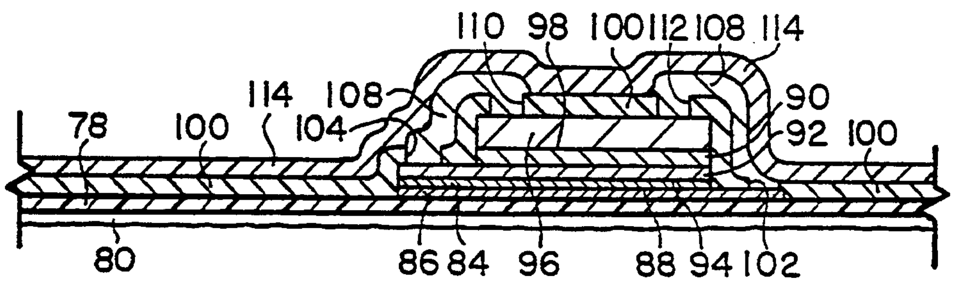


FIG. 6E

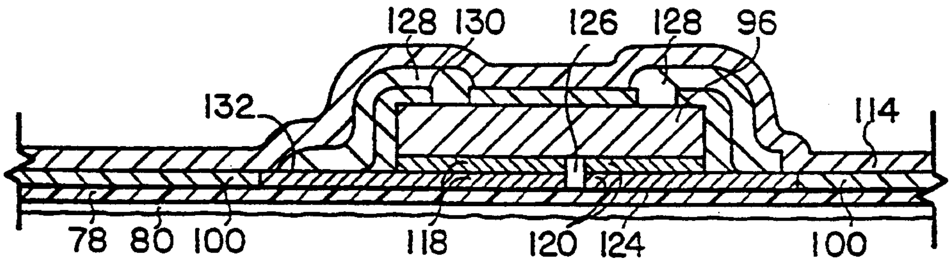


FIG. 7

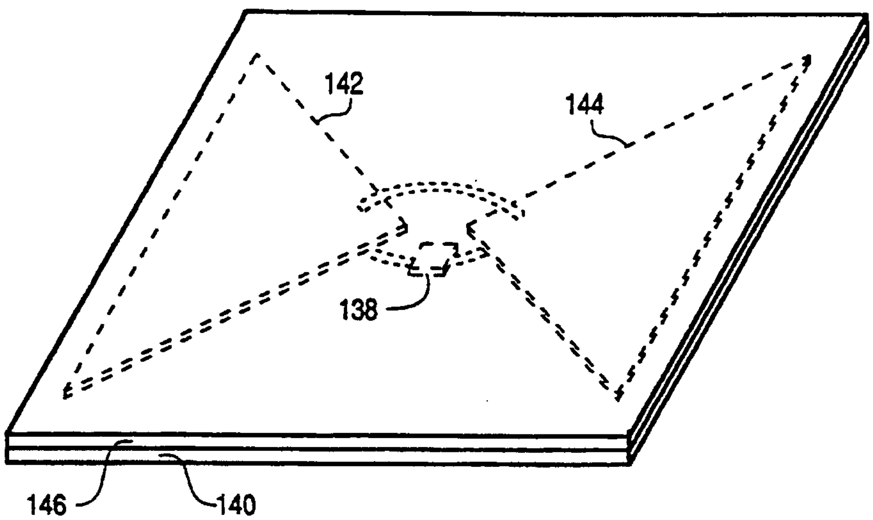


FIG. 8

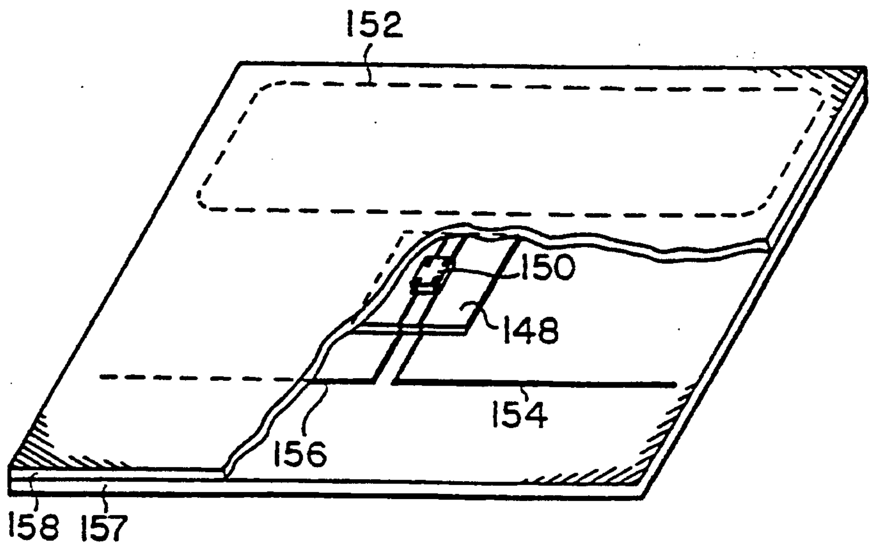


FIG. 9

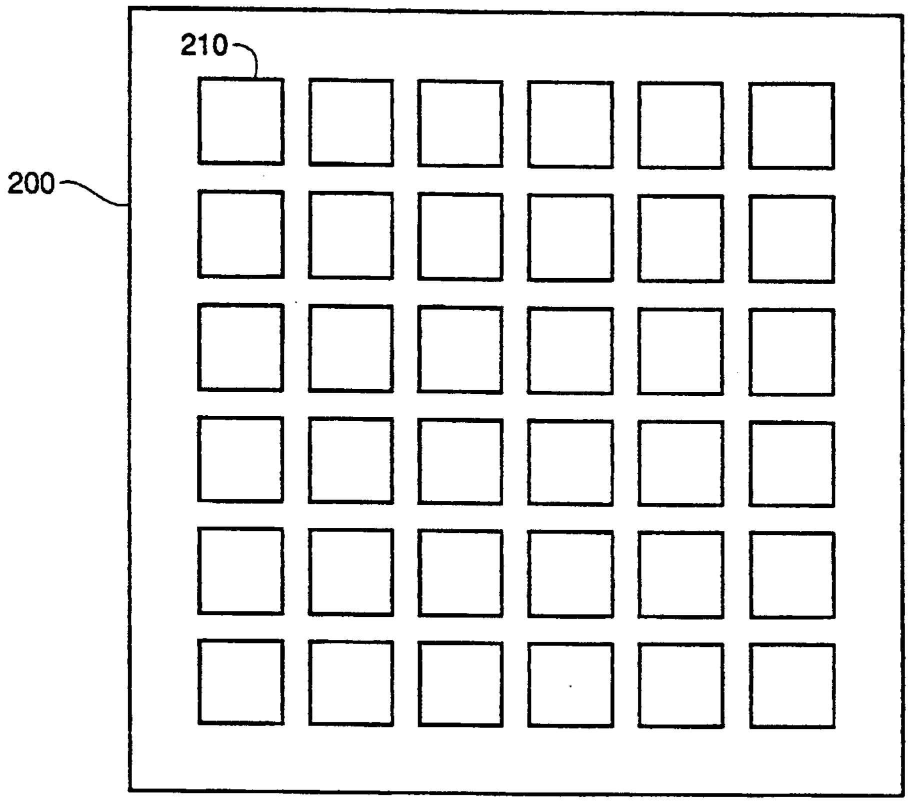


FIG. 10

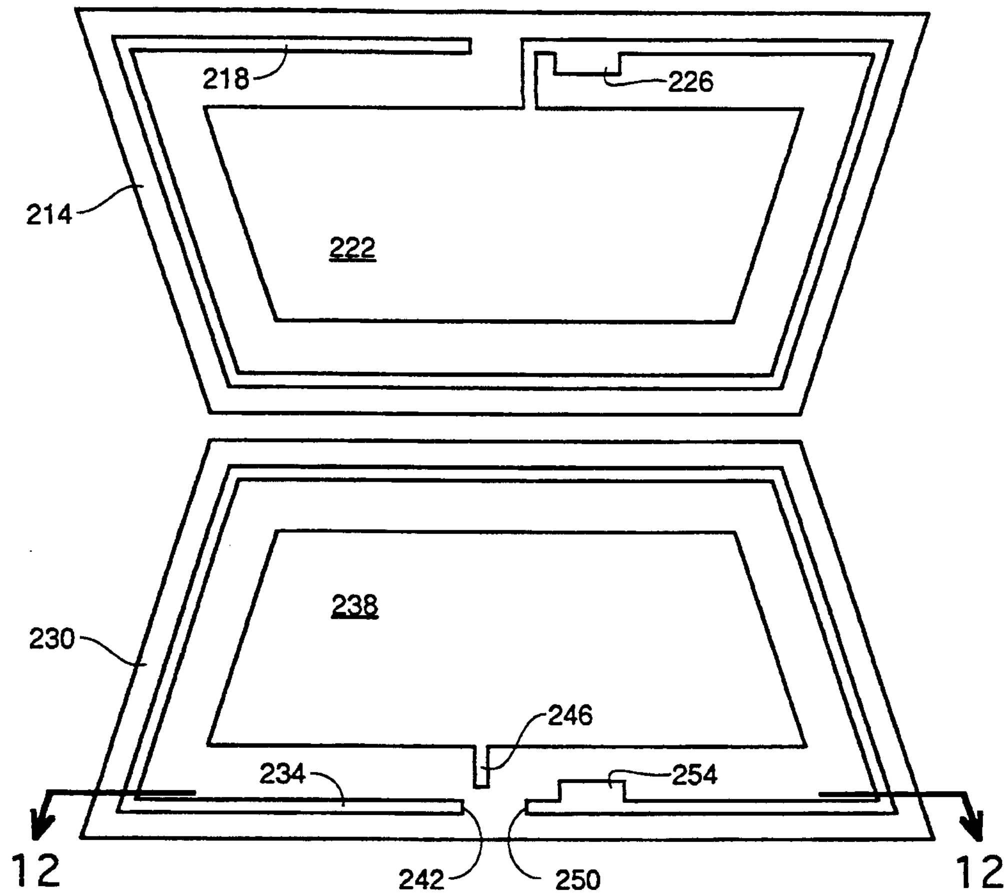

218
226
214
222
230
238
246
234
254
12
242
250
12

FIG. 11

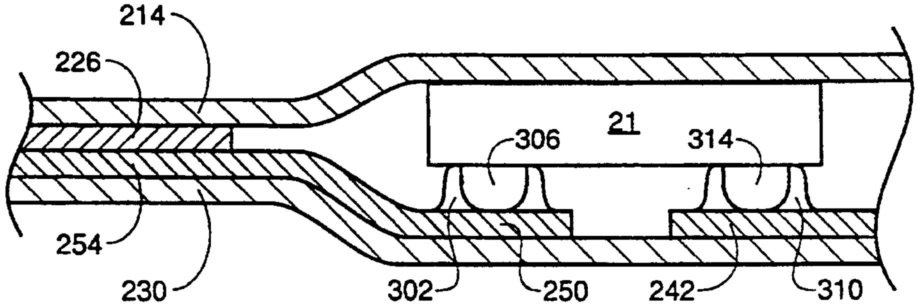

214
226
21
306
314
254
230
302
250
242
310

FIG. 12

ENCLOSED TRANSCEIVER

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation in part application of, and claims priority from, U.S. patent application Ser. No. 07/899,777 filed on Jun. 17, 1992.

TECHNICAL FIELD

The present invention relates generally to enclosed electronic apparatus and to housings that provide circuit connections.

BACKGROUND

As one example of an enclosed electronic apparatus, consider a system for handling baggage in an airport terminal. Such a system incorporates radio frequency identification (RFID) between interrogators and transceivers. In such a system, each baggage tag is an enclosed, battery operated transceiver.

In the field of radio frequency identification (RFID), communication systems have been developed utilizing relatively large packages whose size is on the order of that of a cigarette package or a substantial fraction thereof, and generally speaking, have been fabricated using hybrid circuit fabrication techniques. These relatively large electronic packages have been affixed, for example, to railroad cars to reflect RF signals in order to monitor the location and movement of such cars.

Other smaller passive RFID packages have been developed for applications in the field of transportation, including the tracking of automobiles. These packages include reflective systems of the type produced by Amtech Inc. of Dallas, Tex. However, these reflective passive RFID packages which operate by modulating the impedance of an antenna are inefficient in operation, require large amounts of power to operate, and have a limited data handling capability.

In still other applications of article location and tracking, such as in the postal service or in the field of airline baggage handling and transport, it has not been practical or feasible to use the above relatively large and expensive RFID hybrid packages on smaller articles of transport such as letters, boxed mail shipments or airline luggage. Accordingly, in these latter areas of transport monitoring, as well as many other areas such as inventory control of stored articles, article location and tracking methods have traditionally employed bar code identification and optical character recognition (OCR) techniques which are well known in the art.

Bar code identification and OCR techniques are labor intensive and may, for example, require several airline employees or postal workers to physically manipulate the article and/or the bar code readers to read these bar codes before the transported article reaches its final destination. In addition, the cost of bar code readers and optical character readers is high, limiting the number of locations at which these readers can be used. Furthermore, both bar code readers and optical character readers tend to be highly unreliable.

In yet further and somewhat unrelated fields of: (1) animal tracking and (2) plant tracking, other types of passive RFID tags have been developed by Hughes-/IDI/Destron of Irvine, Calif. These tags utilize a coil wrapped around a ferrite core. Such passive RFID tags have a very limited range, on the order of nine (9) inches, have a very limited data handling capability, and

are not field programmable. In addition, these tags are limited in data storage capacity and are slow in operation.

In view of the problems described above and related problems that consequently become apparent to those skilled in the applicable arts, the need remains for enclosed electronic apparatus including transceivers wherein the enclosure is inexpensive, readily manufactured in high volume, appropriate in size for use as a stamp, label, or tag, and, in the case of transceivers, operable over distances of several hundred feet without regard for the spacial orientation of the enclosure.

SUMMARY

The general purpose and principal object of the present invention is to provide a novel alternative approach to all of the above prior art RFID, OCR, and bar code type location tracking and data storage systems. This new approach as described and claimed herein represents a fundamental breakthrough in the field of article transport control in a wide variety of fields, of which the fields of airline baggage transport, delivery of parcels and mail, and inventory control are only three examples.

To accomplish this purpose and object, we have invented and developed a new and improved radio frequency identification device, an associated electrical system, and a method for communicating with a remote RFID device from a local interrogator and controller. The size of this new device will typically be on the order of one inch square and 0.03 inches thick, or only slightly larger and slightly thicker than a postage stamp. This device includes, in combination, an integrated circuit (IC) which is mounted in an approximately one inch square package and is encapsulated, for example laminated, in a flexible or rigid thin film material. This material may also include a suitable adhesive backing for reliably securing the package to an outer surface or printed label of an article of interest. The IC includes therein a receiver section for driving suitable control logic and memory for decoding and storing input information such as an identification number, the baggage owner's name, point of origin, weight, size, route, destination, and the like. This memory includes, but is not limited to, PROMs, EPROMs, EEPROMs, SRAMs, DRAMs, and ferroelectric memory devices. The IC also includes a transmitter section therein operative for transmitting this information to an interrogator upon subsequent IC interrogation. An RF antenna is placed in a desired geometrical configuration (for example, monopole, dipole, loop, bow-tie, or dual-dipole) and incorporated within or on the thin film material and adjacent to the IC in an essentially two dimensional structure, neglecting the approximately 30 mil thickness dimension of the completed structure.

Advantageously, a thin battery is connected to the IC for providing power to the IC. The IC also incorporates circuitry to allow for operation in a sleep mode during transit and in storage in order to conserve power. Thus, at shipment points of origin, destination, and locations in transit, an operator may encode data into the IC or interrogate the IC by signaling the IC from a remote location to thereby "wake up" the IC without engaging in any hands-on operation.

In a preferred embodiment of the invention, the integrated circuit receiver and transmitter are operated in a spread spectrum mode and in the frequency range of 200 Mhz to 10 GHz, with the range of 800 MHz to 8

GHz being the range of most importance. This operation has the effect of avoiding errors or improper operation due to extraneous signal sources and other sources of interference, multipathing, and reflected radiation from the surrounding environment.

Accordingly, it is a further object of this invention to provide an RFID electronic device of the type described and method of fabricating such device.

Another object of this invention is to provide an RFID system and method of operation of the type described which utilizes RF transmitting and receiving sections on a single IC. Such a system has applications for tracking people or articles in both storage and transit.

Another object of this invention is to provide an electronic device of the type described which does not include bulky hybrid circuits, use modulation techniques described above for passive RFID tags, nor require scanning of bar codes, bar code readers, optical character readers, or especially clean operating environments.

Another object of this invention is to provide an electronic device of the type described which may be manufactured using integrated circuit fabrication and packaging processes.

Another object of this invention is to provide an electronic device of the type described which may be reliably and economically manufactured at high yields and at a high performance to price figure of merit.

Another object of this invention is to provide an RFID device of the type described which is field writable and has a transmission range greater than five (5) feet.

Another object of this invention is to provide a novel assembly process for manufacturing the RFID electronic device described herein.

Another object is to provide a manufacturing process of the type described which is conducive to high speed automation.

Another object is to provide an enclosed electronic device of the type described which is further conducive to high speed product usage, since these RFID devices may be supplied to the customer in a tape and reel format, a fan fold format, or a sheet format.

Another object of this invention is to provide an RFID device of the type described which may be powered with the use of an RF coil and capacitor and without the use of a battery. Such device is also referred to herein as the "passive" device embodiment. However, the term "passive" refers only to the fact that no battery is used, whereas the electrical circuitry on the IC is indeed active while being powered by the RF coil and capacitor combination.

Another object of this invention is to provide a non-contact method of object and person detection and location which can serve as a replacement for metal-to-metal contact in smart card applications and as a replacement for magnetic strip, bar code, and other types of contact-powered electronics. This novel method of object detection and location represents a significant saving of time and manual effort. For example, consider the time and effort involved when a person must first remove a smart card from a pocket or billfold and then insert the card in a card reader device before being allowed entry into a secured area within a building.

Another object of this invention is to provide an electronic device, system, and communication method of the type described which represents, in novel combination, a fundamental breakthrough in many diverse fields of article shipment, including the parcel post and postal fields, the airline industry, inventory control for many manufacturing industries, security, waste management, personnel, and the like.

Accordingly, an enclosed electrical assembly of the present invention includes: a rigid or flexible thin film support member having an integrated circuit (IC) disposed thereon and an antenna incorporated within the IC or positioned adjacent to the IC within a predetermined area of the thin support member; means on the IC for receiving and encoding data relating to the article being stored or shipped; and means on the IC for reading the stored data and transmitting this data to an operator at a remote location.

According to a first aspect of such an assembly, a base member and a cover member each having conductive patterns developed thereon connect the IC in series with two thin film batteries. By arranging two batteries with the IC, no substantial current flows through a laminated or folded portion of the assembly. Smaller signal levels, lower power operation, and longer useful life of the assembly results.

According to another aspect, antenna coupling is also provided to the IC without current flow through a laminated or folded portion of the assembly. Greater sensitivity in receiving and lower losses in transmitting result.

According to another aspect of the present invention, an RFID device has two modes of operation are provided with a wake-up circuit. The wake-up circuit senses in-band energy and switches from a sleep mode to an operating (waked) mode. The sleep mode being useful during transit and storage of the RFID device to conserve battery power.

According to another aspect of such an RFID device, the IC includes receiver and transmitter sections characterized by spread spectrum modulation. Use of spread spectrum modulation reduces data transmission and reception errors, reduces the possibility of improper operation in response to extraneous signal sources, reflected radiation from a surrounding noisy environment, and other interference. Battery power is thereby conserved.

According to another aspect of the present invention, the enclosure includes an adhesive on an outer surface thereof. The adhesive permits reliable and convenient securing of a device of the present invention to an article being transported or stored.

According to yet another aspect of the present invention, by enclosing a transceiver in film, an extremely light weight, durable, and thin package results. Such a package is appropriate for use in replacement of or in conjunction with the conventional handwritten label, conventional hand-cancelled or postage-metered stamp, and the conventional baggage tag.

According to another aspect of the present invention, the frequencies of radio communication, modulation scheme, geometry of the antenna, capacity of the battery, and electrical properties of the enclosure cooperate for omnidirectional communication between an enclosed transceiver of the present invention and a distant interrogator. No manual manipulation of the interrogator or transceiver is required for area-wide communication such as confirming the contents of a delivery vehicle or verifying inventory in place, to name a few examples.

According to an aspect of another embodiment of the present invention, a plurality of transceivers are enclosed and laminated between a pair of films. One side of one of the films has adhesive capability. The transceivers are separated and arranged on a backing. A roll or tape of the backing having transceivers removably attached thereto is enclosed in an RF tight dispenser. The dispenser provides convenient access to unprogrammed transceivers for use on articles to be shipped. When removed from the dispenser, a transceiver communicates with an interrogator in the area for establishing transceiver identity, shipping authorization, destination or storage criteria, date of issue, and similar information. By shielding transceivers within the dispenser from wake-up signals, battery power is conserved.

These and other embodiments, aspects, advantages, and features of the present invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art by reference to the following description of the invention and referenced drawings or by practice of the invention. The aspects, advantages, and features of the invention are realized and attained by means of the instrumentalities, procedures, and combinations particularly pointed out in the appended claims.

DESCRIPTION OF THE DRAWINGS

FIG. **1A** and FIG. **1B** are functional block diagrams of enclosed transceivers of the present invention.

FIG. **2** is a perspective view of an enclosed transceiver as shown in FIG. **1A**.

FIG. **3** is a plan view showing the conductive patterns on the base and cover members used in FIG. **2**, including dotted line outlines of the locations for the IC and batteries.

FIG. **4A** through FIG. **4D** are cross sectional views taken along lines **4—4** of FIG. **3** showing four processing steps used in constructing the enclosed transceiver shown in FIG. **3**.

FIG. **5A** is a perspective view of an alternate embodiment of the invention wherein the IC is mounted on a parallel plate capacitor which in turn is mounted on a battery.

FIG. **5B** is an enlarged portion of FIG. **5A**.

FIG. **6A** through FIG. **6E** are cross sectional views taken along lines **6—6** of FIG. **5** showing five processing steps used in constructing the embodiment shown in FIG. **5**.

FIG. **7** is a cross-sectional view showing an arrangement of battery and capacitor alternate to the embodiment shown in FIG. **5**.

FIG. **8** is a perspective view of another alternate embodiment of the present invention having battery surfaces defining and performing the function of a bow-tie antenna.

FIG. **9** shows an alternate, passive device embodiment of the present invention in partially cut-away perspective view wherein the battery has been altogether eliminated and further wherein a capacitor is periodically charged from an external source in a manner described below to provide operating power to the IC.

FIG. **10** is a top view of a web of enclosed transceivers of the present invention.

FIG. **11** is an exploded perspective view of the top and bottom films used to construct one of the enclosed transceivers shown in FIG. **10**.

FIG. **12** is a cross-sectional view taken along lines **12—12** of FIG. **11** showing a portion of the web shown in FIG. **10** and illustrating electrical coupling to and between the films.

In each functional block diagram, a single line between functional blocks represents one or more signals. A person of ordinary skill in the art will recognize that portions of the perspective views and cross-sectional views are enlarged for clarity.

DESCRIPTION

FIG. **1A** and FIG. **1B** are functional block diagrams of enclosed transceivers of the present invention. Enclosed transceiver **1** includes a pair of batteries **2** and **3**, a dipole antenna **4** and **5**, and an integrated circuit (IC) **11**. Batteries **2** and **3** are in series connection through line **6** and cooperate as powering means for supplying power to IC **11** through lines **8** and **9**. As will be discussed below, the series connection of two batteries simplifies conductor patterns in the enclosure. IC **11** is a four terminal device operating as communicating means for transmitting and receiving radio signals. Dipole antenna **4** and **5** couples radio signals between IC **11** and the communications medium which separates enclosed transceiver **11** from an interrogator, not shown. The interrogator is located up to 400 feet from enclosed transceiver **11**.

Integrated circuit **11** is a transceiver including wake-up circuit **12**, receiver **13**, transmitter **14**, control logic **15**, and memory **16**. Each of these functional circuits receives power signals VCC and GND on lines **8** and **9**. When a received signal has substantial in-band energy as detected by wake-up circuit **12**, control logic **15** enables receiver **13** for receiving and decoding a radio signal on antenna **4** and **5**. Received data is provided by receiver **13** to control logic **15**. Control logic **15** writes received data into memory **16**. Control logic **15** also processes (i.e. decodes, tests, or edits) the received data with data stored in memory **16** and determines whether a response transmission is appropriate and the content of such a response. If a response is appropriate, control logic **15** reads transmit data from memory **16** and enables transmitter **14** for sending the transmit data as a second radio signal on antenna **4** and **5**. Control logic **15** operates as a controller for reading data from and writing data to memory **16**. Antenna **4** and **5** matches the medium to the receiver and to the transmitter for improved receiver sensitivity, and reduced transmission losses. Dipole antenna **4** and **5** has a toroidal antenna pattern with a null along the axis of the toroid.

FIG. **1B** is a functional block diagram of an alternate enclosed transceiver of the present invention. Like numbered elements correspond to elements already described with reference to FIG. **1A**. Enclosed transceiver **18** includes loop antenna **19**, battery **20**, and integrated circuit **21**. Loop antenna **19** provides near omnidirectional communication capability as will be discussed with reference to FIG. **11**.

Battery **20** is connected to antenna line **22** to reduce the number of terminals required to connect integrated circuit **21** into enclosed transceiver **18** and to improve the omnidirectional nature of the antenna pattern. A novel enclosure implements this connection to be discussed below. Integrated circuit **21** is a three terminal device providing the same functions as integrated circuit **11** already described with reference to FIG. **1A**.

As an example of a data call-up operation, consider the events surrounding checking baggage or mailing a

package. When an enclosed transceiver of the present invention is placed on the outside surface of a piece of luggage by the airlines or on a package for shipment by the postal service, an airline agent or postal worker operates an interrogator. The interrogator transmits information to receiver 13 via an RF communication link concerning data such as the owner's name, an ID number, point of origin, weight, size, route, destination, amount of postage prepaid, billing information for debit, postage, handling, or storage costs due, time stamp, and the like. This received data is coupled to control logic 15 for processing, encoding, and storage in memory 16. Stored data is made available for call up by an interrogator at one or more points along the shipment route.

For example, upon reaching a point of shipment destination, an interrogator calls up stored data and uses it at the point of destination for insuring that the item of luggage or shipment is most assuredly and efficiently put in the hands of the desired receiver at the earliest possible time. Specifically, an interrogator at the destination point sends interrogation signals to the enclosed transceiver 1 where they are received by antenna 4 and 5 and first processed by sleep/wake up circuit 12. Wake-up circuit 12 operates to bring integrated circuit 11 out of a "sleep" mode into a "waked" mode wherein receiver 13 receives and decodes signals to provide received data to control logic 15.

With integrated circuit 11 now in "waked" mode, memory 16 is read by control logic 15 to call-up transmit data, i.e. the above six pieces of information relating to the shipped article. Control logic 15 then couples the transmit data to transmitter 14 and enables transmitter 14 for sending transmit data to the interrogator.

Receiver 13 and transmitter 14 preferably employ one of the well known spread spectrum modulation techniques including for example: (1) direct sequencing, (2) frequency hopping, (3) pulsed FM or chirped modulation, (4) time hopping, or (5) time-frequency hopping used with pulse amplitude modulation, simple amplitude modulation or binary phase shift keying.

The communication circuitry of an interrogator (not shown) is designed to conform to the modulation technique, message encoding, and modes of operation described for the enclosed transceivers of the present invention. Interrogator design is understood by those skilled in the art and, therefore, is not described herein.

FIG. 2 is a perspective view of an enclosed transceiver as shown in FIG. 1A. Enclosed transceiver 1 includes a base support layer 30 upon which an integrated circuit 32 is disposed on the near end of layer 30 and connected to a dipole antenna consisting of a pair of conductive strips 34 and 36 extending laterally from IC 32. These conductive strips 34 and 36 will typically be screen printed on the upper surface of base support layer 30.

A pair of rectangularly shaped batteries 38 and 40 are positioned as shown adjacent to IC 32 and are also disposed on the upper surface of base support member 30. Rectangular batteries 38 and 40 are electrically connected in series to power IC 32 in a manner more particularly described below. Assembly of enclosed transceiver 1 is completed by the folding over of an outer or upper cover member 42 which is sealed to the exposed edge surface portions of the base member 30 to thereby provide an hermetically sealed and completed package. When cover member 42 is folded over onto base member 30, conductive strip 50 is attached to batteries 38 and 40 using conductive epoxy. Conductive strip 50 provides means for coupling a pole of battery 38 to a pole of battery 40; thus accomplishing the series electrical connection of batteries 38 and 40. Integrated circuit 32 has transmitter, memory, control logic, and receiver stages therein and is powered by batteries 38 and 40 during the transmission and reception of data to and from an interrogator to provide the interrogator with the various above information and identification parameters concerning the article, animal or person to which the enclosed transceiver is attached.

FIG. 3 is a plan view showing the conductive patterns on the base and cover members used in FIG. 2, including dotted line outlines of the locations for the IC and batteries. During the initial manufacturing stage for the enclosed transceiver, base 30 and cover 42 are joined at an intersecting line 44. Dipole antenna strips 34 and 36 are shown positioned on each side of IC 32. Two conductive strips 46 and 48 serve to connect the bottoms of batteries 38 and 40 to IC 32. Conductive strip 50 is provided on the upwardly facing inside surface of top cover 42, so that, when cover 42 is folded at intersecting line 44, the outer boundary 52 of cover 42 is ready to be sealed with the outer boundary 54 of base support member 30. Simultaneously, conductive strip 50 bonded by the conductive epoxy to batteries 38 and 40, completes the series electrical connection used to connect batteries 38 and 40 in series with each other and further in series circuit with integrated circuit 32 through conductive strips 46 and 48.

FIG. 4A through FIG. 4D are cross sectional views taken along lines 4—4 of FIG. 3 showing four processing steps used in constructing the enclosed transceiver shown in FIG. 3. FIG. 4A shows in cross sectional view IC 32 bonded to base support member 30 by means of a spot or button of conductive epoxy material 56. Conductive strip 48 is shown in cross section on the upper surface of base support member 30.

In FIG. 4B, battery 40 is aligned in place as indicated earlier in FIG. 2 and has the right hand end thereof bonded and connected to the upper surface of conductive strip 48 by means of a spot of conductive epoxy applied to the upper surface of conductive strip 48, but not numbered in this figure.

In FIG. 4C, a stiffener material 58 is applied as shown over the upper and side surfaces of IC 32. The stiffener material will preferably be an insulating material such as "glob-top" epoxy to provide a desired degree of stiffness to the package as completed. Next, a spot of conductive epoxy is applied to each end of conductive strip 50, and then cover layer material 42 with the conductive epoxy thereon is folded over onto batteries 38 and 40 and base member 30 to cure and heat seal and, thus, complete and seal the package in the configuration shown in FIG. 4D.

FIG. 5A is a perspective view of an alternate embodiment of the invention wherein the IC is mounted on a parallel plate capacitor which in turn is mounted on a battery. FIG. 5B is an enlarged portion of FIG. 5A. The enclosed transceiver shown includes the combination of battery 60, capacitor 62, and IC 64. When inrush current requirements for IC 64 exceed the capability of battery 60 to supply surge current, for example, due to inductive coupling or battery structure, inrush current is supplied by capacitor 62. The structure of battery 60 is in direct contact with the upper surface 66 of a base support member 68. The structure of parallel plate capacitor 62 is positioned intermediate to the upper sur-

face of the structure of battery **60** and the bottom surface of IC **64**. In order to facilitate making electrical contacts to capacitor **62** and battery **60**, respectively, an exposed capacitor bottom plate area **65** is provided on the left hand side of this structure and an exposed battery bottom plate area **67** is provided on the right hand side of the battery-capacitor-chip structure. A plurality of antenna lines **70, 72, 74,** and **76** form two dipole antennas connected to opposite corners of IC **64** in a generally X-shaped configuration and extend as shown from IC **64** to the four corners of the package. Upper polymer cover **77** is sealed in place as shown to hermetically seal all of the previously identified elements of the package between base support member **68** and polymer cover **77**.

FIG. **6**A through FIG. **6**E are cross sectional views taken along lines **6—6** of FIG. **5** showing five processing steps used in constructing the embodiment shown in FIG. **5**. Base starting material includes a first or base polymer layer **78**, such as polyester or polyethylene, which is laminated with a relatively impermeable material such as metal film, PVDC, or silicon nitride. Base layer **78** is coated on the bottom surface thereof with a suitable adhesive film **80** which will be used for the device adhesion during device usage. If the adhesive is sufficiently impermeable, the impermeable coating may be omitted. The battery connection and attachment are made on the upper surface of base layer **78** using a spot of conductive epoxy. Conductive epoxy is also used at interface **94** between battery **60** and capacitor **62** and interface **98** between capacitor **62** and IC **64**.

Referring now to FIG. **6**B, a thin film battery consisting of parallel plates **84** and **86** is placed on base layer **78**. Next, a capacitor comprising parallel plates **90** and **92** is attached onto battery layer **84** using a conductive epoxy. Bottom plate **92** of capacitor **62** is somewhat larger in lateral extent than top capacitor plate **90** in order to facilitate the necessary electrical connection of battery **60** and capacitor **62** to integrated circuit **96**. IC **96** corresponds to IC **64** in FIGS. **5**A and **5**B. IC **96** is then attached to top capacitor plate **90** with a conductive epoxy at interface **98**, thereby providing an electrical connection. The bottom surface of IC **96** is metallized to facilitate this connection. In an alternate and equivalent fabrication process, an epoxy cure heat step or metallization anneal step is used to enhance the sealing between the various above stacked elements.

Referring now to FIG. **6**C, prefabricated insulating layer **100** is now laid over the battery/capacitor/IC stack in the geometry shown. Layer **100** includes openings **102, 104, 110,** and **112** therein for receiving a conductive polymer material as will be described below in the following stage of the process. Prefabricated holes **102, 104, 110,** and **112** in layer **100** are aligned, respectively, to the battery contact, to the capacitor contact, and to the contacts on the top of IC **96**. Layer **100** is then sealed to base polymer layer **78** using, for example, a conventional heating or adhesive step.

Referring now to FIG. **6**D, a conductive polymer material **108** is deposited in openings **102** and **104** in the lower regions of layer **100** and extended up into the upper openings **110** and **112** of layer **100** to make electrical contact as indicated on the upper surface of IC **96**. The shaped conductive epoxy material **108** may also be preformed utilizing a stamping tool or silk screening techniques and is applied as shown over the upper surface of layer **100**. Conductive epoxy material **108** forms the innermost region of the antenna structure extending from IC **96** out in the dual dipole geometry as previously described with reference to FIGS. **5**A and **5**B. However, the complete antenna geometry shown in FIG. **5**A is outside the lateral bounds of the fragmented cross sectional views shown in FIGS. **6**A through **6**E. At this point in the process, an epoxy cure heat step is optional.

Referring now to FIG. **5**E, polymer insulating layer **114** is formed on the upper surface of layer **100** in the geometry shown and further extends over the exposed upper surfaces of the conductive epoxy polymer antenna material **108**. Layer **114** is then sealed to layer **100** using either heat or adhesive sealing. Layer **114** provides a final hermetic seal for the completed device shown in cross section in FIG. **6**E.

FIG. **7** is a cross-sectional view showing an arrangement of battery and capacitor alternate to the embodiment shown in FIG. **5**. As shown in FIG. **7**, the battery and capacitor are mounted side-by-side under the IC. The electrical connection for battery **118** and capacitor **120** to integrated circuit **96** is provided by positioning the battery **118** and capacitor **120** in the co-planar configuration shown on the surface of base polymer layer **78**. The bottom plate of battery **118** is connected through conductive epoxy layer **128** to the top surface of IC **96**. The bottom plate of parallel plate capacitor **120** is connected through conductive epoxy layer **128** to the top surface of the IC **96**. A small space **126** is provided as shown to electrically isolate battery **118** and capacitor **120**. In addition, in this embodiment of the invention, conductive material **128** is extended as shown between the left side opening **130** in the layer **100** and a lower opening **132** in layer **100**. In a manner similar to that described above with reference to FIGS. **6**A through **6**E, layer **114** is then extended over the top surface of layer **100** in the geometry shown. Conductive polymer material **128** extends to connect the crossed antenna structure of FIG. **5** to IC **96** shown in FIG. **7**.

FIG. **8** is a perspective view of another alternate embodiment of the present invention having battery surfaces defining and performing the function of a bow-tie antenna. IC **138** is centrally positioned as shown on the upper surface of base support member **140** and is electrically connected to two triangularly shaped batteries **142** and **144**, also disposed on the upper surface of base support member **140**. Batteries **142** and **144** are connected in series with IC **138** when protective cover member **146** is sealed over the top surfaces of the two batteries **142** and **144** and the IC **138** using processing steps previously described.

In the embodiment of the invention shown in FIG. **8**, the entire outer surfaces of the two batteries **142** and **144** serve as a "bow tie" antenna structure for the enclosed transceiver. At communication wavelengths, the top and bottom surfaces of batteries **142** and **144** are coupled together. Batteries **142** and **144** are connected in series with the IC **138** to provide DC operating power therefor in a manner previously described. Moreover, the dual use of the batteries as power supplies and antenna structures minimizes the number of terminals required to connect IC **138** into an enclosed transceiver.

FIG. **9** shows an alternate, passive device embodiment of the present invention in partially cut-away perspective view wherein the battery has been altogether eliminated and further wherein a capacitor is periodically charged from an external source in a manner described below to provide operating power to the IC. This embodiment is known as the passive or battery-

less device embodiment, since it contains no battery therein. Instead, operating power is provided by a capacitor structure identified as component **148** located beneath IC **150**. A charge on capacitor **148** is maintained by conventional RF charging circuits (not shown) on IC **150** which are energized from a remote source.

The enclosed transceiver shown in FIG. **9** includes a first loop antenna **152** for receiving RF charging signals for capacitor **148** and a dipole antenna formed of conductive strips **154** and **156** for receiving and transmitting data to and from IC **150**. As in previous embodiments, capacitor **148** and IC **150** are positioned and hermetically sealed between a base cover member **157** and a top cover member **158**.

FIG. **10** is a top view of a web of enclosed transceivers of the present invention. Laminated sheet **200** includes **36** enclosed transceivers **210** simultaneously manufactured in a plurality of cavities as already described. Sheet **200** in a preferred embodiment includes **252** enclosed transceivers, each approximately 1.5 inches square. Alternatively, sheet **200** includes one folded film as illustrated in FIGS. **2**, **3**, and **4**; three coextensive films **114**, **100**, and **78** as illustrated in FIGS. **6** and **7**; or two coextensive films as is apparent from FIGS. **8** and **9**, and FIGS. **11** and **12** to be discussed below. Sheet **200**, in one embodiment is sectioned to obtain individual enclosed transceivers by interstitial cutting, perforation and tearing, or sheering; sectioning being simultaneous with or following the step of sealing each enclosed cavity by lamination, embossing, hot stamping or the like. Alternatively enclosed transceivers are manufactured in a continuous strip, for example, one enclosure.

After manufacturing has been completed, a large number of finished devices, or webs are stored on a take-up reel (not shown) supporting a corresponding large plurality of the devices. Advantageously, storage on a take-up reel not only makes the present process conducive to high speed automated manufacturing, but in addition makes the process compatible to high speed manual or automated product dispensing and use. Large numbers of enclosed transceivers may be supplied easily to a user in a conventional tape and reel format. The user can readily cut off one device at a time for immediate attaching to an article. Alternatively, enclosed transceivers are manufactured and shipped in sheets and later sectioned by the customer.

In yet another embodiment, devices are cut from the tape or sheet from which they were manufactured and then removably mounted on a backing. The backing in one embodiment is in tape format and in another equivalent embodiment is in sheet format. When mounted to a backing, enclosed transceivers are more effectively stored in a cache for dispensing individually. The cache, not shown, includes means for dispensing (i.e. separately providing a transceiver on demand) and shielding means for preventing signal reception by enclosed transceivers within the cache. If shielding were not included, a supply of transceivers located within communicating range of an interrogator would soon expend battery capacity by processing signals including, for example, wake-up signals. Means for dispensing includes, for example, mechanical devices for feeding a tape or sheet through an opening and mechanical devices for separating shielding materials from a tape or sheet. The former dispensing means, in one embodiment of the cache, cooperates with shielding across the opening including conductive rollers, separating brushes, separating fingers, and the like. The latter dispensing means, in another embodiment of the cache, cooperates with conductive backing material, or conductive foam as a backing or cover layer arranged to shield the exposed edges of a roll containing transceivers.

FIG. **11** is an exploded perspective view of the top and bottom films used to construct one of the enclosed transceivers shown in FIG. **10**. The embodiment shown corresponds to enclosed transceiver **18** shown in FIG. **1B**. Top film **214** includes area **222** for lamination onto the top surface (pole) of battery **20**; strip **218** for loop antenna **19**; and, contact area **226**. Each of these three features, in a preferred embodiment, is formed of conductive ink. In an alternate and equivalent embodiment, these three features are formed of conductive epoxy. Bottom film **230** includes area **238** for lamination onto the bottom surface (pole) of battery **20**; strip **234** for loop antenna **19**; contact area **254**; and contact points **242**,**246**, and **250** for connecting integrated circuit **21** to the battery and antenna. Each of these six features, in a preferred embodiment, is formed of conductive ink, though conductive epoxy is equivalent.

Contact **246** is intentionally misaligned with respect to area **222** to prevent shorting battery **20**. However, strips **218** and **234** are aligned to coincide, as are contact areas **226** and **254**, respectively. These strips and contact areas when joined by lamination cooperate as means for coupling power from battery **20** to IC **21** and, simultaneously, for electrically matching IC **21** to the communications medium by forming loop antenna **19**. Thus, contacts **242**, **246**, and **250** correspond respectively to lines **24**, **23**, and **22** shown in FIG. **1B**.

Unlike the antenna pattern of the dipole antenna shown in FIGS. **1A**, **2**, **3**, and **9**, there is no null in the antenna pattern for loop antenna **19**, due in part to the conductive structure of battery **20** being connected to one side of loop antenna **19**. The combined loop antenna and battery structure is also preferred over the dipole in that the combination provides an antenna pattern that is less subject to variation over a broad range of frequencies.

FIG. **12** is a cross-sectional view taken along lines **12**—**12** of FIG. **11** showing a portion of the web shown in FIG. **10** and illustrating electrical coupling to and between the films. The completed assembly includes similarly numbered elements already discussed with reference to FIG. **11**. IC **21** is prepared for assembly by curing conductive epoxy bumps **306** and **314** to terminals on its lower surface. IC **21** as shown is in a flip chip packaging orientation having substantially all circuitry formed on the surface facing film **230**. Prior to assembly, a puddle of conductive epoxy is applied to contacts **250** and **242**. IC **21** is then located atop contacts **250** and **242** so that bumps **306** and **314** are surrounded within puddles **302** and **310**. Finally, top film **214** is aligned over bottom film **230** so that contact areas **226** and **254** are pressed together. The films are then heated to set all conductive epoxy including puddles **302** and **310**, as well as strips and areas including the antenna and contact areas **226** and **254**, formed of conductive epoxy.

Various modifications may be made in and to the above described embodiments without departing from the spirit and scope of this invention. For example, various modifications and changes may be made in the antenna configurations, battery arrangements (such as battery stacking), device materials, device fabrication steps, and the functional block diagrams without de-

parting from the scope of this invention. The various off-chip components such as the antenna, battery, and capacitor are manufactured on-chip in alternate and equivalent embodiments. As a second example, the antenna in another alternate and equivalent embodiment is formed on the outer surface or within the outer film. In such an arrangement, coupling to the antenna is through the capacitance of the outer film as a dielectric. When formed on the exterior, the material comprising the antenna also provides hermeticity to the film for protecting the enclosed transciever. Accordingly, these and equivalent structural modifications are within the scope of the following appended claims.

As previously suggested, an enclosed transceiver used as an RFID device has utility directed to a wide variety of applications including, but not limited to, airline baggage (luggage, freight, and mail); parcel post (Federal Express and United Parcel Service); U.S. Mail; manufacturing; inventory; personnel security.

While the particular invention has been described with reference to illustrative embodiments, this description is not meant to be construed in a limiting sense. It is understood that although the present invention has been described in a preferred embodiment, various modifications of the illustrative embodiments, as well as additional embodiments of the invention, will be apparent to persons skilled in the art, upon reference to this description without departing from the spirit of the invention, as recited in the claims appended hereto. It is, therefore, contemplated that the appended claims will cover any such modifications or embodiments as fall within the true scope of the invention.

The words and phrases used in the claims are intended to be broadly construed. A "sticker" refers generally to a label, tag, marker, stamp, identifier, packing slip, invoice, package seal, tape, band, clasp, medallion, emblem, shield, and escutcheon regardless of printed or handwritten material thereon. Mechanical coupling of a "sticker" so defined to an article, person, plant, or animal is not restricted to adhesive but is intended to broadly include all forms of fastening, tieing, and securing.

What is claimed is:

1. A sticker comprising:
   a. a first film comprising a first surface and a second surface substantially parallel to the first surface, the second surface comprising a plurality of conductors;
   b. a first battery comprising a first pole and a second pole, the first pole coupled to a first conductor of the plurality;
   c. a second battery comprising a third pole and a fourth pole, the fourth pole coupled to a second conductor of the plurality;
   d. an integrated circuit mounted superjacent to the second surface and coupled to the first conductor and the second conductor of the plurality;
   e. a second film placed superjacent to the second surface, the second film comprising means for coupling the second pole to the third pole; and
   f. means for mechanically coupling the sticker to an article of manufacture.

2. The sticker of claim 1 wherein the second film is sealed to the second surface.

3. The sticker of claim 1 wherein a third conductor of the plurality forms an antenna and the integrated circuit is coupled to the third conductor.

4. The sticker of claim 1 wherein the first battery comprises a conductive surface and the integrated circuit is coupled to the conductive surface so that the conductive surface operates as an antenna.

5. A sticker comprising:
   a. a first film comprising a first surface and a second surface substantially parallel to the first surface, the second surface comprising a first plurality of conductors;
   b. a battery mounted superjacent to the second surface, the battery comprising a first pole and a second pole, the first pole coupled to a first conductor of the first plurality;
   c. an integrated circuit mounted superjacent to the second surface and coupled to the first conductor;
   d. a second film placed superjacent to the second surface, the second film comprising an antenna, a second conductor coupled to the antenna and coupled to the second pole, the second conductor for coupling the antenna and the battery to the integrated circuit; and
   e. means for mechanically coupling the sticker to an article of manufacture.

6. The sticker of claim 5 wherein the integrated circuit comprises:
   a. a memory;
   b. a receiver for receiving a first radio signal and providing received data;
   c. a controller for writing the received data into the memory and for reading transmit data from the memory; and
   d. a transmitter for sending the transmit data as a second radio signal.

7. The sticker of claim 6 wherein the integrated circuit further comprises processing means for editing the transmit data in response to the received data.

8. The sticker of claim 7 wherein the transmit data includes data for billing a cost associated with handling of the article.

9. The sticker of claim 5 wherein the integrated circuit comprises a common terminal for coupling to the battery and for coupling to the antenna.

* * * * *

US005519201A

United States Patent [19]

Templeton, Jr. et al.

[11] **Patent Number: 5,519,201**

[45] **Date of Patent: May 21, 1996**

[54] **ELECTRICAL INTERCONNECTION FOR STRUCTURE INCLUDING ELECTRONIC AND/OR ELECTROMAGNETIC DEVICES**

[75] Inventors: **Thomas H. Templeton, Jr.**, Fremont; **Charles F. Horejs, Jr.**, Morgan Hill, both of Calif.

[73] Assignee: **US³, Inc.**, Santa Clara, Calif.

[21] Appl. No.: **235,820**

[22] Filed: **Apr. 29, 1994**

[51] **Int. Cl.**[6] **H05K 7/10**

[52] **U.S. Cl.** **235/492**; 29/832; 361/737; 439/66

[58] **Field of Search** 439/66, 68, 74, 439/91, 76; 361/737, 760, 761, 763, 764; 235/488, 492; 29/830, 832, 842

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,680,037	7/1972	Nellis et al.	439/66
3,702,464	11/1972	Castrucci	340/173 SP
3,971,916	7/1976	Moreno	235/61.7 B
4,338,621	7/1982	Braun	257/697
4,420,767	12/1983	Hodge et al.	439/71
4,539,622	9/1985	Akasaki	361/764
4,742,385	5/1988	Kohmoto	439/68
4,954,308	9/1990	Yabe et al.	264/272.17
4,960,983	10/1990	Inoue	235/488
5,018,051	5/1991	Yamada et al.	235/492
5,109,320	4/1992	Bourdelaise et al.	36/764

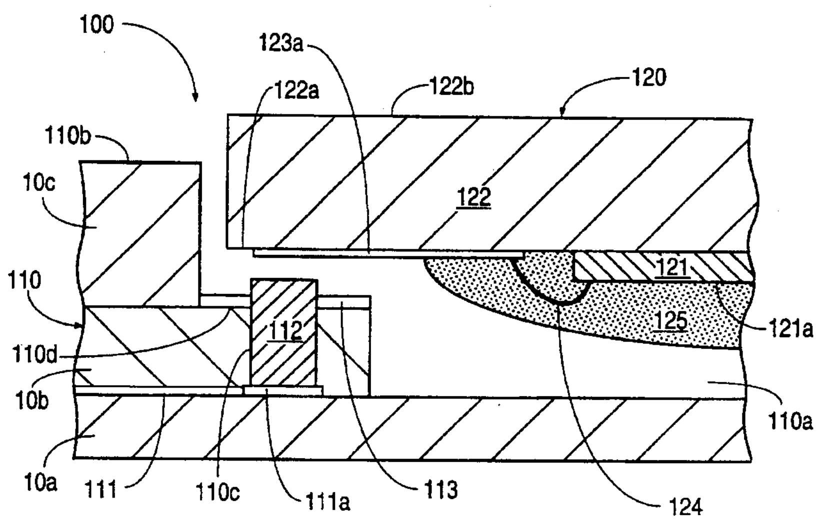
Primary Examiner—Neil Abrams

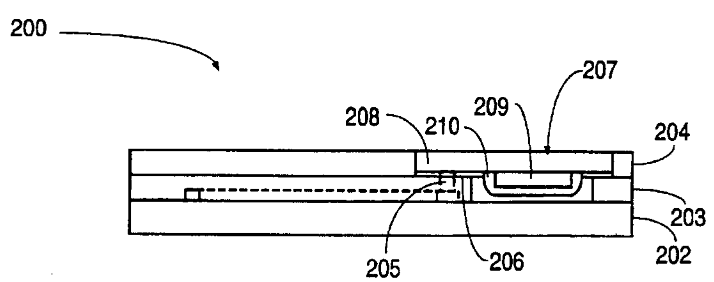
Attorney, Agent, or Firm—Skjerven, Morrill, MacPherson, Franklin & Friel; E. Eric Hoffman

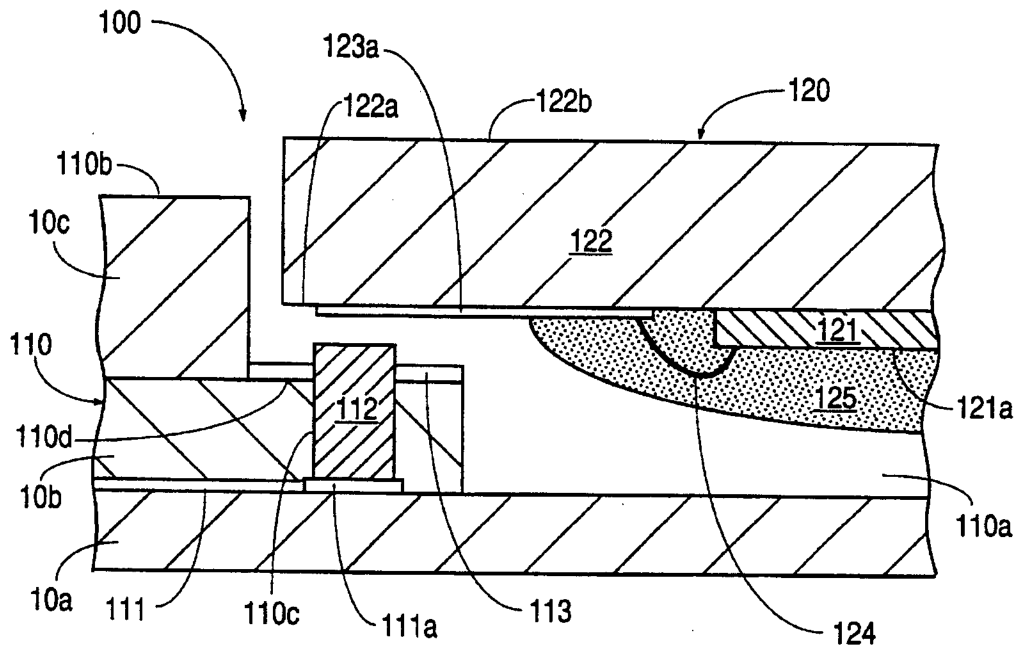
[57] **ABSTRACT**

A flexible structure includes two or more electronic and/or electromagnetic devices, electrical connection being made between the devices by flexible and compressible electrically conductive plugs located within cavities or holes formed within the flexible structure. The structure is assembled so that the plugs are compressed between electrical contacts formed on or connected to the respective devices. As a result, good electrical contact is maintained between the devices. Additionally, if the structure is flexible, when the flexible structure is bent or deformed, the plugs bend or deform with the rest of the flexible structure so that the electrical connections between the plugs and the respective device electrical contacts are not broken.

12 Claims, 6 Drawing Sheets

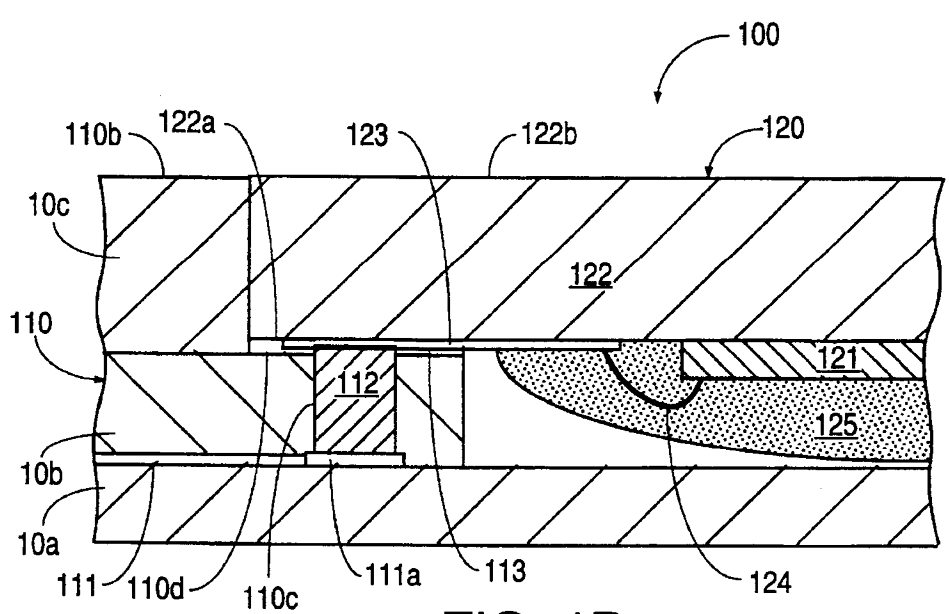






100
123a
122a
122b
120
110b
10c
122
110
121
112
125
121a
110d
10b
110a
10a
111
110c
111a
113
124

FIG. 1A



100
110b
122a
123
122b
120
10c
122
110
121
112
125
10b
10a
111
110d
110c
111a
113
124

FIG. 1B

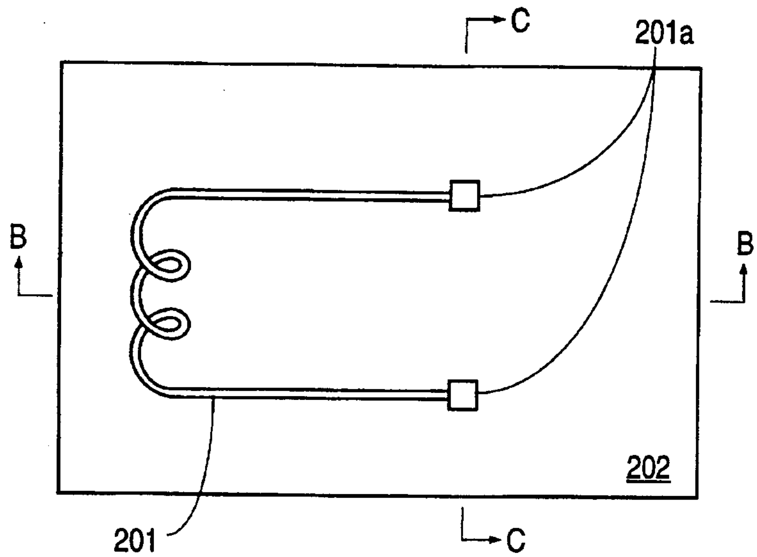


FIG. 2A

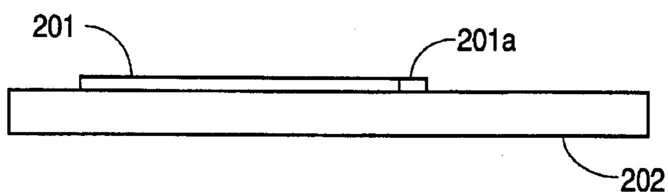


FIG. 2B

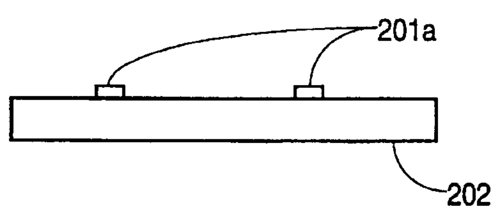


FIG. 2C

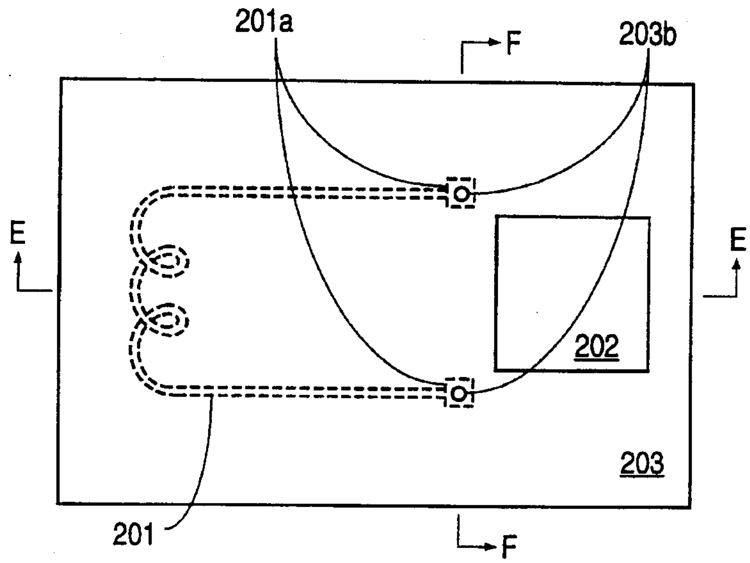


FIG. 2D

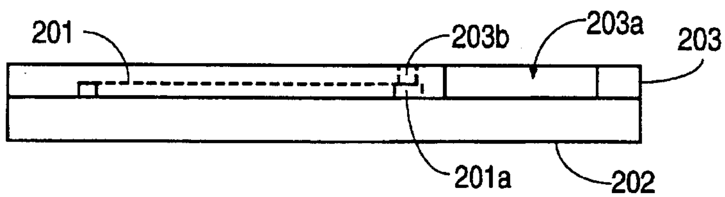


FIG. 2E

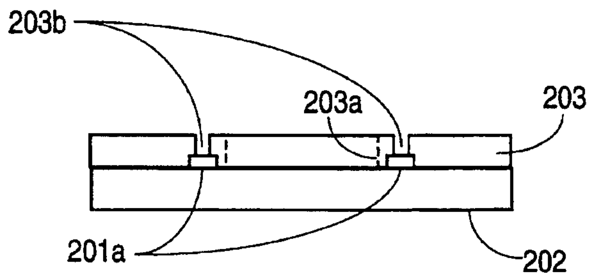


FIG. 2F

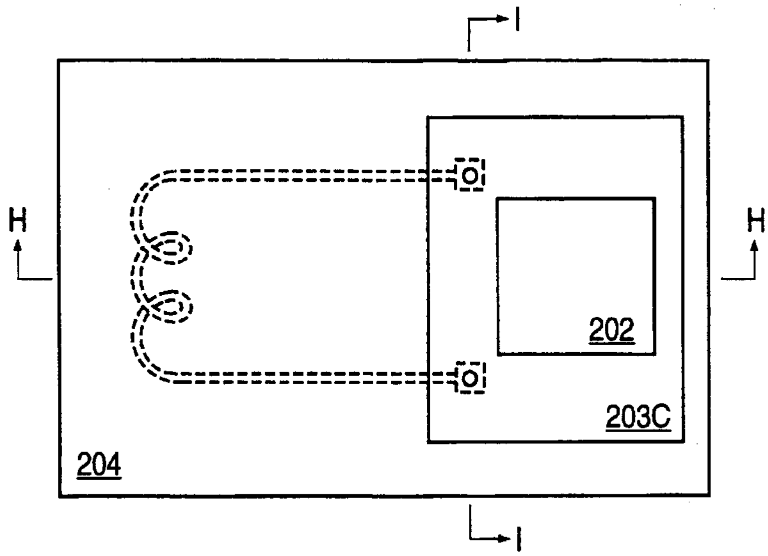


FIG. 2G

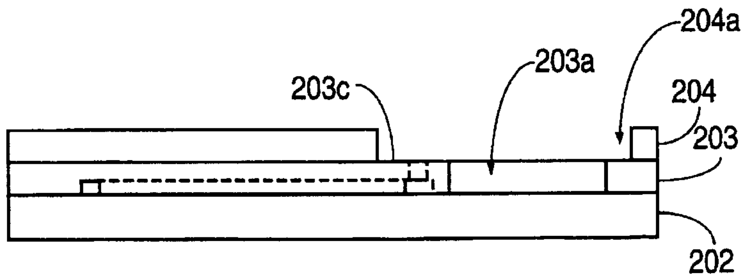


FIG. 2H

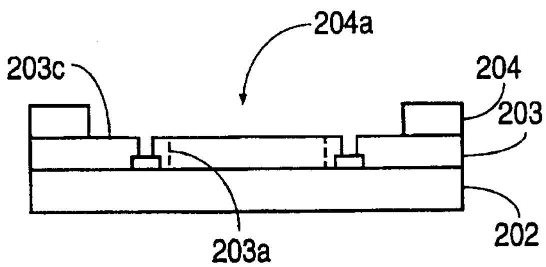


FIG. 2I

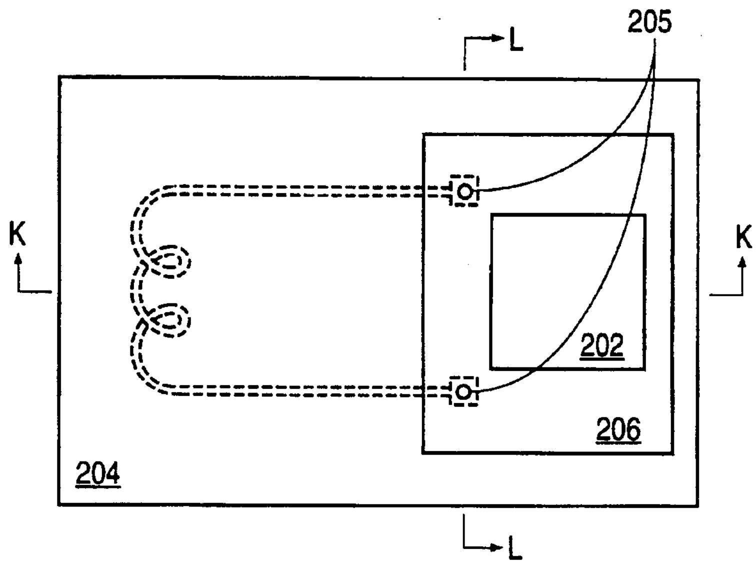


FIG. 2J

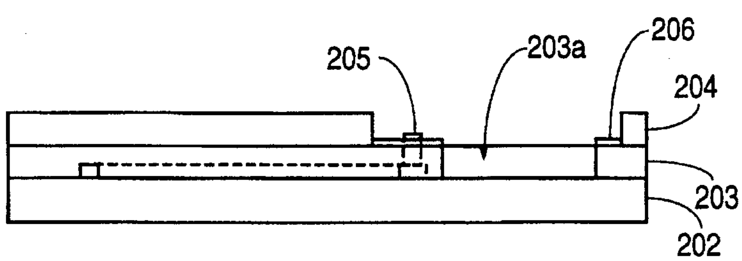


FIG. 2K

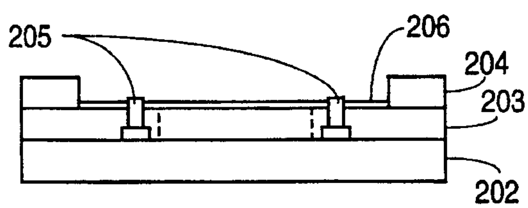


FIG. 2L

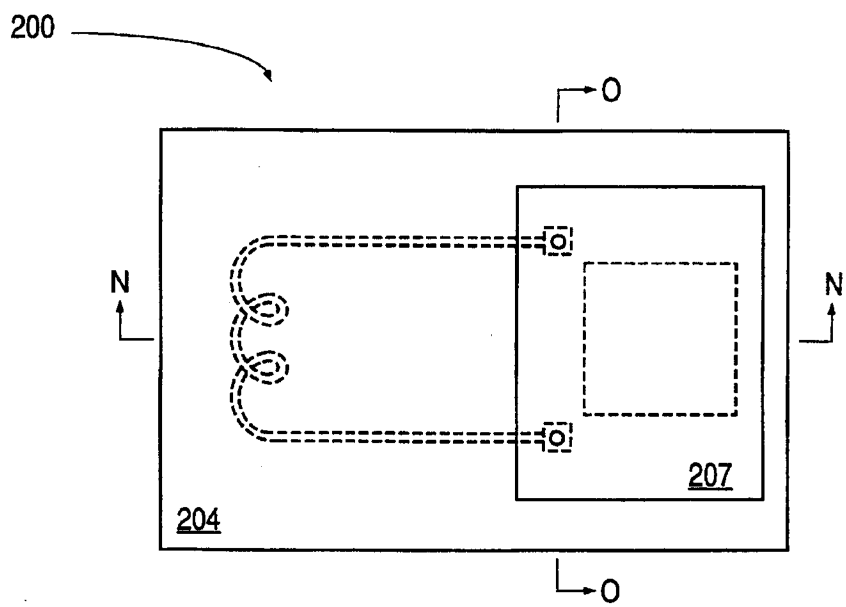


FIG. 2M

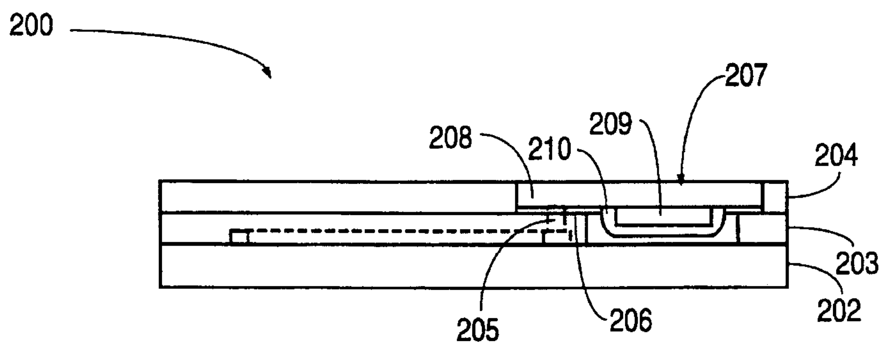


FIG. 2N

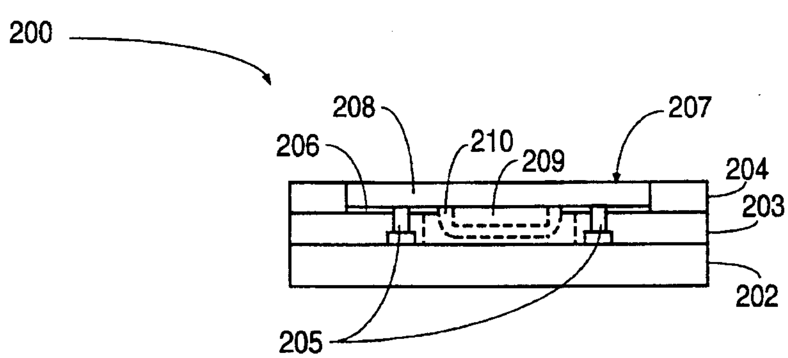


FIG. 2O

ELECTRICAL INTERCONNECTION FOR STRUCTURE INCLUDING ELECTRONIC AND/OR ELECTROMAGNETIC DEVICES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a flexible structure including electronic and/or electromagnetic devices and, in particular, to a contact structure for electrically connecting the devices so that electrical contact between the devices is maintained when the flexible structure is bent or otherwise deformed.

2. Related Art

There are a wide variety of applications that can make use of a flexible structure including electronic and/or electromagnetic devices, the devices being used for information input and output to and from the flexible structure, information processing and information storage. One example of such a flexible structure is a flexible identification card.

An identification card, as defined by the International Standards Organization (ISO) in ISO 7810, is "[a] card identifying its bearer and issuer which may carry data required as input for the intended use of the card and for transactions based thereon." Identification cards can have one of three nominal sizes (as specified in ISO 7810): 1) 3.370 inch (85.60 mm) width, 2.125 inch (53.98 mm) height, 0.030 inch (0.76 mm) thickness; 2) 4.134 inch (105 mm) width, 2.913 inch (74 mm) height, 0.030 inch (0.76 mm) thickness; 3) 4.921 inch (125 mm) width, 3.465 inch (88 mm) height, 0.030 inch (0.76 mm) thickness.

Some identification cards include an integrated circuit and are known as "integrated circuit cards" or "Smart Cards." More generally, herein, "Smart Card" refers to any portable card-like device which includes one or more electronic components, i.e., active components such as integrated circuits, transistors and diodes, and passive components such as resistors, capacitors and inductors. The integrated circuits can be formed on an integrated circuit chip and/or printed circuit board that is, in turn, attached to the main body of the Smart Card. Smart Cards can be used for a wide variety of applications such as prepaid "debit" cards (e.g., phone cards, transit passes, electronic purse), subscriber cards (e.g., bank ATM cards, credit cards, point-of-sale cards), loyalty scheme cards (e.g., frequent flier cards), security access and identification cards, health insurance and service cards (with optional protected memory), GSM (global system management for European Cellular Phones) cards and encryption/decryption cards.

Smart Cards are used with a reader/writer that includes an interface ("external interface") that is used to transmit information to or from the Smart Card. Some Smart Cards include electrical contacts which are used to make electrical connection between electrical circuitry on or within the Smart Card and the external interface. Other Smart Cards do not include electrical contacts and accomplish the transfer of information to and from the Smart Card through another means such as, for example, an inductive coil formed in or on the Smart Card that is used in combination with an external interface that produces and responds to an electromagnetic field, i.e., electromagnetic contact-less Smart Cards. Other types of contact-less cards use electro-static or capacitive coupling to accomplish the transfer of data and instructions to and from the card.

In Smart Cards (and other structures such as printed circuit boards, for example) including two or more electronic or electromagnetic devices, it is generally necessary

or desirable to electrically interconnect the devices. Typically, in Smart Cards, this is done within the main body of the Smart Card. Electrical interconnection is made between electrical contacts on the respective devices, e.g., electrically conductive traces on a printed circuit board, electrically conductive bond pads on an integrated circuit chip, terminal points of an inductive coil.

In some previous flexible structures including two or more electronic or electromagnetic devices, electrical interconnection has been made between the devices by soldering or welding the respective electrical contacts together, or by attaching the respective electrical contacts with an electrically conductive adhesive. However, when the flexible structure is bent, the relatively rigid (as compared to the flexible structure) solder, weld or adhesive can break, resulting in failure or degradation of the electrical interconnection. Further, soldering or welding the respective electrical contacts together is a difficult task since it is difficult to position the soldering or welding equipment within a cavity formed in the main body of the card for placing one of the devices, e.g., an integrated circuit module. Additionally, most flexible Smart Cards (as well as many other flexible structures) are made of low temperature plastic which undesirably melts at the temperatures necessary for soldering, welding or heating an adhesive.

In other previous flexible structures including two or more electronic or electromagnetic devices, electrical interconnection has been made by forming holes through the main body of the card, the holes extending between the respective electrical contacts of the devices, then inserting copper "studs" into the holes which are attached at either end to the respective electrical contacts by soldering, welding or use of an electrically conductive adhesive. However, when the flexible structure bends, the rigid copper studs do not, so that, frequently, one or more of the copper studs break away from one or both of the electrical contacts, thereby breaking the electrical interconnection between the devices.

SUMMARY OF THE INVENTION

According to the invention, a structure includes two or more electronic and/or electromagnetic devices, electrical connection being made between the devices by flexible and compressible electrically conductive plugs located within cavities or holes formed within the flexible structure. The structure is assembled so that the plugs are compressed between electrical contacts formed on or connected to the respective devices. As a result, good electrical contact is maintained between the devices. Further, if the structure is a flexible structure, then, when the flexible structure is bent or deformed, the plugs bend or deform with the rest of the flexible structure so that the electrical connections between the plugs and the respective device electrical contacts are not broken.

Any number of electronic and/or electromagnetic devices can be included within the structure according to the invention, and the devices can be of any type such as an integrated circuit modules, transistors, diodes, and passive components such as resistors, inductors and capacitors. Further, an integrated circuit module for use with the invention can be a printed circuit board to which is attached one or more integrated circuit chips, a printed circuit board without an integrated circuit chip attached, or just an integrated circuit chip.

In one embodiment of the invention, the first device is an inductive coil supported by the main body of the structure and the second device is an integrated circuit module

including an integrated circuit chip attached to a printed circuit board, bond pads on the chip being wirebonded to electrically conductive traces or regions on the printed circuit board.

The plugs can be made of any flexible, compressible, electrically conductive material or combination of materials. In one embodiment, each of the plugs are a "Fuzz Button," i.e., a metallic conductor formed as, for instance, a group of knotted strands ("Fuzz"), or a set of parallel filaments, springs or platelets, enclosed in an elastomeric material such as Shin Etsu's Polymer MAF.

In certain embodiments of the invention, the structure is a "Smart Card". However, the invention applies broadly to any structure including electrically interconnected devices, such as printed circuit boards, and is particularly useful in such structures that are flexible.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a cross-sectional view of a portion of a structure according to an embodiment of the invention just prior to attachment of an integrated circuit module to the main body of the structure.

FIG. 1B is a cross-sectional view of the portion of the structure of FIG. 1A after attachment of the integrated circuit module to the main body of the structure.

FIGS. 2A through 2O illustrate steps in a process for forming a contact-less integrated circuit card according to an embodiment of the invention. FIGS. 2A, 2B and 2C are a plan view, a cross-sectional view taken along section B—B of FIG. 2A, and a cross-sectional view taken along section C—C of FIG. 2A, respectively, illustrating an inductive coil formed on a surface of a first substrate that is part of the main body of a contact-less integrated circuit card. FIGS. 2D, 2E and 2F are a plan view, a cross-sectional view taken along section E—E of FIG. 2D, and a cross-sectional view taken along section F—F of FIG. 2D, respectively, illustrating a second substrate that is formed on the first substrate to cover the inductive coil. FIGS. 2G, 2H and 2I are a plan view, a cross-sectional view taken along section H—H of FIG. 2G, and a cross-sectional view taken along section I—I of FIG. 2G, respectively, illustrating a third substrate formed on the second substrate to define a mounting surface for an integrated circuit module on the second substrate. FIGS. 2J, 2K and 2L are a plan view, a cross-sectional view taken along section K—K of FIG. 2J, and a cross-sectional view taken along section L—L of FIG. 2J, respectively, illustrating flexible, compressible electrically conductive plugs inserted in contact holes formed through the second substrate and an adhesive formed on the mounting surface of the second substrate. FIGS. 2M, 2N and 2O are a plan view, a cross-sectional view taken along section N—N of FIG. 2M, and a cross-sectional view taken along section O—O of FIG. 2M, respectively, illustrating attachment of an integrated circuit module to the mounting surface of the second substrate so that electrical contact is made between the plugs and electrical contact points on the integrated circuit module.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

According to the invention, a structure includes two or more electronic and/or electromagnetic devices, electrical connection being made between the devices by flexible and compressible electrically conductive plugs. The plugs are located within cavities or holes formed within the structure. The structure is assembled so that the plugs are compressed between electrical contacts formed on or connected to the respective devices.

Compression of the plugs results in a compressive force that pushes the plugs against the respective electrical contacts, thereby maintaining good electrical contact between the devices. Further, in structures according to the invention that are flexible, when the flexible structure is bent or otherwise deformed, the flexibility of the plugs allows the plugs to bend or deform with the rest of the flexible structure so that the electrical connections between the plugs and the respective device electrical contacts are not broken, thus preventing disablement of the electronic and/or electromagnetic capacity of the flexible structure.

FIG. 1A is a cross-sectional view of a portion of a structure **100** according to an embodiment of the invention just prior to attachment of an integrated circuit module **120** to a main body **110** of the structure **100**. FIG. 1B is a cross-sectional view of a portion of the structure **100** of FIG. 1A after attachment of the integrated circuit module **120** to the main body **110** of the structure **100**.

In structure **100**, the integrated circuit module **120** is attached to the main body **110** which includes layers **10*a***, **10*b*** and **10*c***, and an electrically conductive trace **111** (which may be an inductive coil). As described in more detail below in connection with FIGS. 2A–2O, layers **10*a***, **10*b*** and **10*c*** are attached with an adhesive and/or laminated. It is to be understood that this embodiment is merely illustrative and that a wide range of combinations of electronic and/or electromagnetic devices can be used in a structure according to the invention. A structure according to the invention can include any kind and number of electronic and electromagnetic devices (e.g., integrated circuit modules, transistors, diodes, and passive components such as resistors, inductors and capacitors).

Further, the integrated circuit module **120** of structure **100** includes an integrated circuit chip **121** attached to a printed circuit board **122**. However, this need not be the case. An integrated circuit module for use with the invention could also be a printed circuit board without an integrated circuit chip attached, a printed circuit board with more than one integrated circuit chip attached, or just an integrated circuit chip.

The integrated circuit chip **121** is attached to the printed circuit board **122** using conventional techniques and adhesives. Electrically conductive traces **123** are formed on the printed circuit board **122** using conventional techniques. Any desired pattern of electrically conductive traces and electrically conductive regions (e.g., ground planes, power planes) can be formed on the surface **122*a*** of the printed circuit board **122**. The electrically conductive traces **123** (and electrically conductive regions, if present) are made of any conventional printed circuit board metallization material. Bond pads (not shown) are formed on the surface **121*a*** of the integrated circuit chip **121**. Each of selected ones of the bond pads are connected to a corresponding electrically conductive trace **123** by a bond wire **124** using conventional wirebonding techniques. The integrated circuit chip **121** is then encapsulated by a molding compound **125** by, for instance, potting.

The integrated circuit chip **121** can be attached to the printed circuit board **122** and electrically connected to the electrically conductive traces **123** other than as described above. For example, controlled collapse chip connection can be used to directly attach the bond pads of the integrated circuit chip **121** to the electrically conductive traces **123** of the printed circuit board **122** so that the surface **121*a*** of the

integrated circuit chip **121** is adjacent the surface **122a** of the printed circuit board **122**.

Additionally, the integrated circuit chip **121** can be attached to a leadframe or a set of leads on TAB tape and the leads attached to the main body **110**.

The main body **110** is formed with a cavity **110a** in which the integrated circuit module **120** fits such that the surface **122b** of the printed circuit board **122** is substantially planar with the surface **110b** of the main body **110** (see FIG. **1B**) when the integrated circuit module **120** is attached to the main body **110**. The electrically conductive trace **111** is formed of, for example, copper plated with nickel and gold, and has electrical contact pads **111a** at terminal ends. The contact pads **111a** are formed of, for example, copper plated with nickel and gold, and are positioned at locations that correspond to the locations of electrically conductive traces **123** on the printed circuit board **122**. Each of a plurality of holes **110c** are formed through the main body **110** to extend from one of the contact pads **111a** to a mounting surface **110d** of the main body **110**. An adhesive **113** is formed on the mounting surface **110d** so that the adhesive **113** does not cover the holes **110c**. An electrically conductive plug **112** is placed within each hole **110c** such that the plug **112** extends above the adhesive **113** (FIG. **1A**) before attachment of the integrated circuit module **120** to the main body **110**. Although only one conductive trace **111**, contact pad **111a**, hole **110c** and conductive trace **123** are illustrated in FIGS. **1A** and **1B**, it will be appreciated that a plurality may be used, for example, as illustrated in FIGS. **2A** through **2O**.

As seen in FIG. **1B**, when the integrated circuit module **120** is attached to the main body **110**, the plugs **112** are compressed. (Though, in FIG. **1A**, the plug **112** is shown as having the same diameter as the hole **110c**, in practice, the plug **112** must have a slightly smaller diameter to accommodate the compression of the plug **112** which expands the plug **112** to increase the diameter of the plug **112**.) The adhesive **113** holds the integrated circuit module **120** in place within the cavity **110a** in the main body **110** so that the plugs **112** remain compressed after formation of the structure **100** is complete.

The plugs **112** are made of any flexible, compressible, electrically conductive material or combination of materials, as described in more detail below. Thus, compression of the plugs **112** causes a compressive force in the plugs **112** that presses the plugs **112** against the electrically conductive traces **123** and the contact pads **111a** so that good electrical contact is maintained. Further, since the plugs **112** are made of an elastomeric material, if the structure **100** is flexible, when the structure **100** is bent or otherwise deformed, the plugs **112** bend or deform also, reducing stresses at the interface between the plug **112** and the electrically conductive trace **123**, and the interface between the plug **112** and the contact pad **111a**. Thus, bending of the structure **100** does not cause the plugs **112** to break away from either the electrically conductive traces **123** or the contact pads **111a**, so that the electronic and/or electromagnetic functions of the structure **100** are not disabled.

FIGS. **2A** through **2O** illustrate steps in a process for forming an electromagnetic contact-less integrated circuit card according to an embodiment of the invention. However, it is to be understood that the invention is applicable to any type of structure including two or more electronic and/or electromagnetic devices and that the process described is merely illustrative of the possible processes for forming a structure according to the invention.

FIGS. **2A**, **2B** and **2C** are a plan view, a cross-sectional view taken along section B—B of FIG. **2A**, and a cross-sectional view taken along section C—C of FIG. **2A**, respectively, illustrating an inductive coil **201** formed on a surface of a first substrate **202** that is part of the main body of an electromagnetic contact-less integrated circuit card. In FIGS. **2A**, **2B**, **2C** (and FIGS. **2D** through **2O** below), for simplicity, the inductive coil **201** is shown schematically using the well known symbol for an inductor. It is to be understood that, in reality, the inductive coil **201** can be formed in any appropriate shape. In one embodiment, the inductive coil **201** is formed as a spiral. The spiral is formed in three dimensions such that the outer "end" of the spiral and the inner "end" of the spiral are in different planes so that the inner "end" of the spiral can be extended to a contact pad (described in more detail below) located outside of the outermost turn of the spiral.

The first substrate **202** is formed of any suitable material. In embodiments in which the structure according to the invention is flexible, the first substrate **202** is formed of one or more layers of a flexible material such as, for example, poly-vinyl-chloride, polyimide, FR4 (fiberglass), bituminous resin, polysulfone, polycarbonate or ABS (acrylonitrile-butadiene-styrene). If desired, different materials can be used for different layers of the substrate **202**. The number and types of materials of layers included in the first substrate **202** (and the other substrates described below) depends upon the manufacturing techniques used, the characteristics of the material being used and the mechanical performance requirements of the electromagnetic contact-less integrated circuit card.

If more than one layer is used for the first substrate **202**, preferably, the layers are attached with adhesives and then laminated (i.e., fused together under heat and pressure to form a unitary structure). Any of a number of different adhesives can be used, such as rubber-based adhesives, solvent and latex based adhesives, thermoplastic hot melt, iscoyanate-based adhesives, PUR (polyurethanes), epoxy resin, polysulfide sealants and adhesives, reactive acrylate-based adhesives, cyanoacrylates and silicones. However, the layers need not be laminated and can be attached only with adhesives. Alternatively, if the layers are laminated, the layers need not be first attached with an adhesive.

The inductive coil **201** is formed in or on the surface of the first substrate **202** with a shape and of a material determined according to principles well-known in the art of coil forming. For example, inductive coil **201** can be formed in a spiral, as described above, of any desired electrically conductive material such as, for example, copper. Inductive coil **201** is formed using any of a number of conventional processes and equipment that are well known in the art of coil forming. For example, inductive coil **201** can be formed using conventional lithographic techniques.

The contact pads **201a** are formed at terminal ends of the inductive coil **201**. The contact pads **201a** can be formed by, for example, stamping the terminal ends of inductive coil **201**. Alternatively, contact pads **201a** can be attached to the terminal ends of inductive coil **201** by, for example, spot welding or soldering. The contact pads **201a** can be made of, for example, copper, stainless steel, nickel or brass. The contact pads **201a** can be plated with gold, if desired.

FIGS. **2D**, **2E** and **2F** are a plan view, a cross-sectional view taken along section E—E of FIG. **2D**, and a cross-sectional view taken along section F—F of FIG. **2D**, respectively, illustrating a second substrate **203** that is formed on the first substrate **202** to cover the inductive coil **201**. Like the first substrate **202**, the second substrate **203** can include one or more layers. The layers of the second substrate **203**

are made of materials as described above and can be different from each other and/or different from the layers of the first substrate **202**. The second substrate **203** is attached to the first substrate **202** with an adhesive and laminated, just attached with an adhesive, or just laminated.

Contact holes **203*b*** are formed through the second substrate **203** at locations that correspond to the location of the contact pads **201*a*** of the inductive coil **201**. A cavity hole **203*a*** into which an integrated circuit module will be positioned is also formed through the second substrate **203**. The contact holes **203*b*** and cavity hole **203*a*** can be formed either before or after attaching the second substrate **203** to the first substrate **202**. The contact holes **203*b*** and cavity hole **203*a*** can be formed by, for instance, punching, stamping, chemical etching, mechanical or laser drilling, or milling.

FIGS. 2G, 2H and 2I are a plan view, a cross-sectional view taken along section H—H of FIG. 2G, and a cross-sectional view taken along section I—I of FIG. 2G, respectively, illustrating a third substrate **204** formed on the second substrate **203** to define a mounting surface **203*c*** for an integrated circuit module on the second substrate **203**. Like the first substrate **202** and second substrate **203**, the third substrate **204** can include one or more layers. The layers of the third substrate **204** are made of materials as described above and can be different from each other and/or different from the layers of the first substrate **202** and/or second substrate **203**. The third substrate **204** is attached to the second substrate **203** with an adhesive and laminated, just attached with an adhesive, or just laminated.

A cavity hole **204*a*** is formed through the third substrate **204** at a location such that, when the third substrate **204** is attached to the second substrate **203**, the cavity hole **204*a*** defines a shelf **203*c*** on a surface of the second substrate **203** that surrounds the cavity hole **203*a*** formed through the second substrate **203**. The cavity hole **204*a*** can be formed either before or after attaching the third substrate **204** to the second substrate **203**. The cavity hole **204*a*** can be formed by, for instance, punching, stamping, chemical etching, mechanical or laser drilling, or milling.

FIGS. 2J, 2K and 2L are a plan view, a cross-sectional view taken along section K—K of FIG. 2J, and a cross-sectional view taken along section J—J of FIG. 2J, respectively, illustrating flexible, compressible electrically conductive plugs **205** inserted in the contact holes **203*b*** and an adhesive **206** formed on the mounting surface **203*c*** of the second substrate **204**. Insertion of the plugs **205** into the contact holes **203*b*** and formation of the adhesive **206** on the mounting surface **203*c*** can occur in any order. In another embodiment of the invention, an electrically conductive adhesive is formed on opposite ends of the plugs **205** to help adhere the plugs **205** to the contact pads **201*a*** and to electrical contact points formed on the integrated circuit module **207** (discussed in more detail below).

The adhesive **206** can be a liquid glue, e.g., a cyanoacrylic glue such as Locktite, which is dispensed on to mounting surface **203*c*** using conventional equipment and processes. The glue dispensing equipment is controlled (either manually or by computer-controlled robotic dispenser) so that glue does not enter the contact holes **203*b*** (if the adhesive **206** is formed before insertion of the plugs **205**) or contact

the plugs **205** (if the adhesive **206** is formed after insertion of the plugs **205**).

Alternatively, adhesive **206** can be a solid material, e.g., double-sided sticky tape. The solid material is patterned with holes and a cavity that correspond to the contact holes **203*b*** and cavity **203*a***, then adhered to mounting surface **203*c***.

Or, adhesive **206** can be a thermosetting resin such as epoxy resin. The thermosetting resin can be patterned with holes and a cavity, as above, and placed on mounting surface **203*c***, or the thermosetting resin can be dispensed on to mounting surface **203*c***. The thermosetting resin is then heated and cooled after the integrated circuit module is placed within cavities **203*a*** and **204*a***, as explained below.

The plugs **205** are placed either robotically or manually in the contact holes **203*b*** using conventional tools and processes. In the electromagnetic contact-less integrated circuit card according to the invention shown in FIGS. **2A** through **2O**, there are two contact holes **203*b*** and plugs **205**, one at each terminal end of the inductive coil **201**. However, it is to be understood that in other embodiments of a structure according to the invention including other types or quantities of electronic or electromagnetic devices, a lesser or greater number of contact holes **203*b*** and plugs **205** can be formed. Further, even in the electromagnetic contact-less integrated circuit card shown in FIGS. 2A through 2O, it is possible and perhaps desirable to form additional, redundant sets of contact pads **201*a***, contact holes **203*b*** and plugs **205** to increase the reliability of the electromagnetic contact-less integrated circuit card.

The plugs **205** and contact holes **203*b*** are shown in FIGS. **2D** through **2O** as having a circular cylindrical shape. However, cylindrical shapes having other cross-sectional shapes, e.g., rectangular, can be used. The height of the plugs **205** is chosen to be slightly greater than the combined thickness of the second substrate **203** and the adhesive **206**, so that when the integrated circuit module is attached, as explained below, the plugs **205** are compressed. Further, the cross-sectional dimensions of the plugs **205**, e.g., diameter, or width and length, are made slightly smaller than the corresponding dimensions of the contact holes **203*b*** so that, when the plugs **205** are compressed, there is room within the contact holes **203*b*** for the plugs **205** to expand.

As noted above, the plugs **205** can be formed of any flexible, compressible, electrically conductive material or combination of materials. In one embodiment, the plugs **205** are made of an anisotropically electrically conductive elastomeric material. In a further embodiment, the plugs **205** are a metallic conductor enclosed in an elastomeric material such as, for example, an intrinsically conductive polymer (ICP). The metallic conductor is, for instance, a group of knotted strands, or a set of parallel filaments, springs or platelets. The plugs **205** according to this embodiment of the invention are either molded, extruded and cut, or die punched. Plugs **205** according to this embodiment of the invention are commercially available as "Fuzz Buttons" from Trw/Cinch located in Elk Grove Village, Ill. Plugs **205** can also be polymer MAF available from Shin Etsu Polymer America located in Union City, Calif. Whatever material is used for plugs **205**, it is necessary or desirable to specify certain characteristics of plugs **205**: electrical properties such as, for example, resistance and, where appropriate,

inductance; geometric dimensions; and mechanical properties such as, for example, spring constant.

FIGS. 2M, 2N and 2O are a plan view, a cross-sectional view taken along section N—N of FIG. 2M, and a cross-sectional view taken along section O—O of FIG. 2M, respectively, illustrating attachment of an integrated circuit module **207** to the mounting surface **203*b*** of the second substrate **203** so that electrical contact is made between the plugs **205** and electrical contact points (not shown) on the integrated circuit module **207**. The electrical contact points can be either a portion of an electrically conductive trace, or an electrically conductive contact pad formed at the end of an electrically conductive trace. Attachment of the integrated circuit module **207** completes formation of the electromagnetic contact-less integrated circuit card **200**.

The integrated circuit module **207** includes a conventional integrated circuit chip **209** attached to a conventional printed circuit board **208** (e.g., an FR4 printed circuit board with metallization made of copper plated with nickel and gold) and enclosed by an encapsulant **210**. The integrated circuit chip **209** is attached to the printed circuit board **208** using conventional adhesives. Bond pads (not shown) on the integrated circuit chip **209** are electrically connected with bond wires (not shown) to electrically conductive traces and/or regions formed on a surface of the printed circuit board **208** using conventional wirebonding techniques. The encapsulant **210** is formed by potting to enclose the integrated circuit chip **209** and bond wires. However, note that formation of encapsulant **210** is not absolutely necessary and, in other embodiments of the invention, the encapsulant **210** is not present.

The integrated circuit module **207** is positioned within the cavities **203*a*** and **204*a*** on the adhesive **206**, either manually or robotically using conventional equipment and processes, so that each of the electrical contact points on the printed circuit board **208** contacts a corresponding one of the plugs **205**. Pressure is applied to the integrated circuit module **207** so that the plugs **205** are compressed. If a thermosetting resin is used as adhesive **206**, the resin is heated and then cooled while the pressure is applied. The adhesive **206** holds the integrated circuit module **207** in place, keeping the plugs **205** compressed so that good electrical contact is maintained between each of the plugs **205** and the corresponding contact pad **201*a*** and electrical contact point of the printed circuit board **208**.

In embodiments of a structure according to the invention other than that shown in FIGS. 2A through 2O, electrically conductive circuitry and regions can be formed in any desired pattern according to well known techniques on one or more of the layers of the main body. Vias may also be formed according to well known techniques through one or more layers of the main body to electrically connect electrically conductive material formed on different layers of the main body.

Various embodiments of the invention have been described. The descriptions are intended to be illustrative, not limitative. Thus, it will be apparent to one skilled in the art that certain modifications may be made to the invention as described without departing from the scope of the claims set out below.

I claim:

1. A smart card comprising:

a first flexible layer;

a first electrical contact located over a first surface of the first layer;

a first electronic or electromagnetic device for controlling said smart card disposed on the first layer, wherein the first electrical contact is coupled to the first device;

a second flexible layer located over the first surface of the first layer and the first electrical contact, the second layer having an opening which extends through the second layer to expose the first electrical contact, and wherein a cavity is formed in the second layer;

a third layer located over the second layer;

a second electrical contact located over the third layer, the second and third layers being positioned such that the second electrical contact is disposed between the second and third layers, and over the opening;

a second electronic or electromagnetic device for controlling said smart card disposed on the third layer, wherein the second electrical contact is coupled to the second device, and wherein the second device is disposed in the cavity in the second layer; and

a flexible, compressible electrically conductive plug located within the opening, the plug being compressed between the first electrical contact and the second electrical contact to make electrical connection therebetween.

2. The smart card of claim **1**, wherein the second device is an integrated circuit module.

3. Structure as in claim **2**, wherein the integrated circuit module further comprises an integrated circuit chip.

4. The smart card of claim **3**, wherein the third layer comprises a printed circuit board.

5. The smart card of claim **4** further comprising:

an electrically conductive trace located on a surface of the printed circuit board, wherein the trace is electrically connected to the second electrical contact;

an electrically conductive bond pad located on a surface of the integrated circuit chip; and

means for electrically connecting the bond pad to the trace on the printed circuit board.

6. The smart card of claim **2**, wherein the first device is an inductive coil fabricated over the first surface of the first layer.

7. The smart card of claim **1**, wherein the plug is made of an anisotropically electrically conductive elastomeric material.

8. The smart card of claim **7**, wherein the plug is a fuzz button.

9. The smart card of claim **1**, further comprising a flexible fourth layer located over the second layer, wherein the fourth layer has an opening which laterally surrounds said third layer.

10. A method for constructing a smart card, the method comprising the steps of:

providing a first flexible layer;

forming a first electrically conductive trace over a first surface of the first flexible layer, the first trace having a first electrical contact;

affixing a first electronic or electromagnetic device over the first surface of the first layer, whereby the first device is coupled to the first trace;

providing a second flexible layer;

forming an opening through the second flexible layer;

forming an cavity in the second flexible layer;

placing an flexible, compressible, electrically conductive plug in the opening;

affixing the second layer to the first layer such that the opening is aligned with the first electrical contact;

providing a third layer;

forming a second electrically conductive trace over a second surface of the third layer, the second trace having a second electrical contact;

affixing a second electronic or electromagnetic device

over the second surface of the third layer, whereby the second device is coupled to the second trace;

affixing the third layer to the second layer, such that the opening is aligned with the second electrical contact, the second device is disposed in the cavity, and the plug is compressed between the first and second electrical contacts.

11. A method as in claim **10**, wherein the first device comprises an inductive coil.

12. A method as in claim **10**, wherein the the second device is an integrated circuit module.

* * * * *

US005567362A

United States Patent [19]

Grün

[11] Patent Number: 5,567,362

[45] Date of Patent: Oct. 22, 1996

[54] **IDENTITY CARD AND A METHOD AND APPARATUS FOR PRODUCING IT**

[75] Inventor: **Herbert Grün**, Vaterstetten, Germany

[73] Assignee: **GAO Gesellschaft fur Automation und Organisation mbH**, Germany

[21] Appl. No.: **288,041**

[22] Filed: **Aug. 10, 1994**

Related U.S. Application Data

[63] Continuation of Ser. No. 992,725, Dec. 18, 1992, abandoned.

[30] **Foreign Application Priority Data**

Dec. 20, 1991 [DE] Germany 41 42 408.5

[51] **Int. Cl.^{6}** **B29C 45/16**; B42D 15/10; G06K 19/18

[52] **U.S. Cl.** **264/1.31**; 264/255; 264/139; 264/273; 264/328.8; 264/245; 428/137; 428/916; 283/108; 283/904

[58] **Field of Search** 264/245, 255, 264/328.8, 294, 273, 1.31, 139; 428/67, 140, 138, 139, 137, 916, 141, 156, 142; 283/904, 107, 108, 109, 111

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,226,408	12/1940	Nast	264/328.8
2,333,059	10/1943	Tucker	264/328.8
3,031,722	5/1962	Gits	264/255
3,363,039	1/1963	Nagai et al.	264/255
5,030,406	7/1991	Sorensen	264/255
5,045,268	9/1991	Sorensen	264/255

FOREIGN PATENT DOCUMENTS

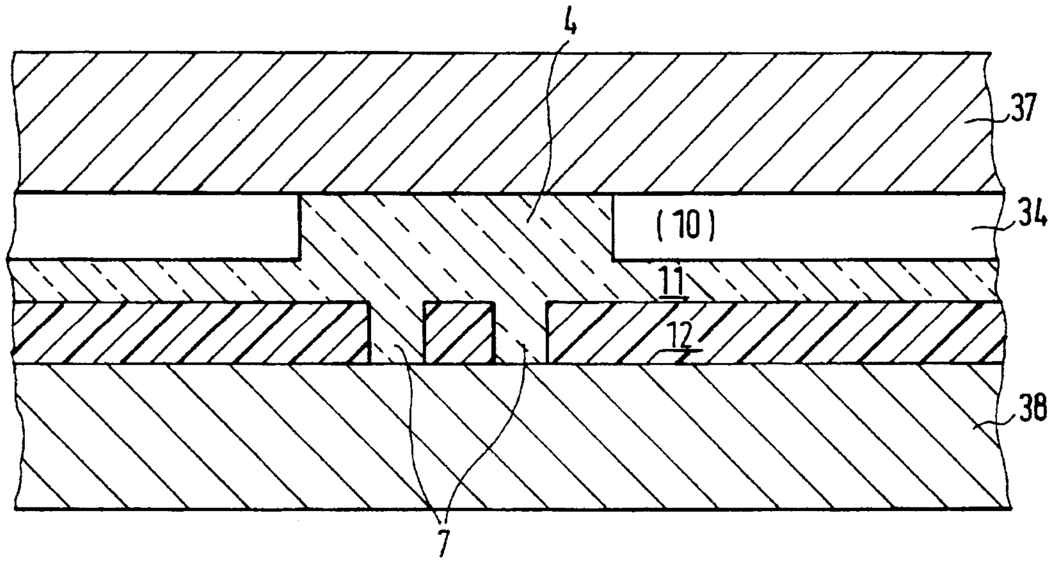
62-80028	4/1987	Japan	264/1.31
62-233234	10/1987	Japan	264/1.31

Primary Examiner—Jill L. Heitbrink
Attorney, Agent, or Firm—Bacon & Thomas

[57] **ABSTRACT**

The invention relates to a flat molding produced by the injection molding technique, in particular an identity card, chip card or the like, characterized in that it has different volume areas containing different plastic components and formed and disposed so as to be distinguishable from one another visually and/or by measuring technology.

6 Claims, 3 Drawing Sheets



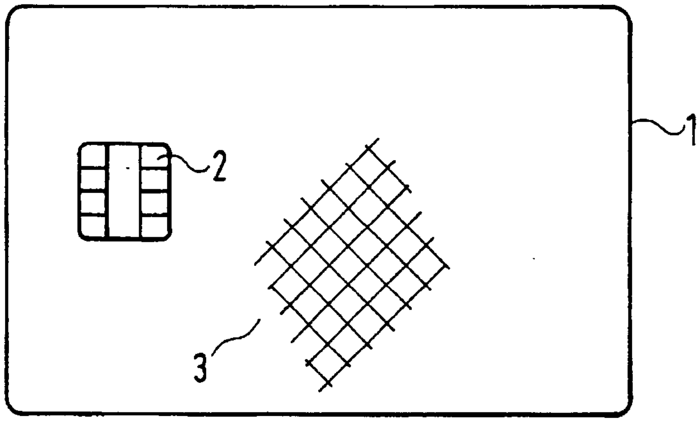


FIG. 1
(PRIOR ART)

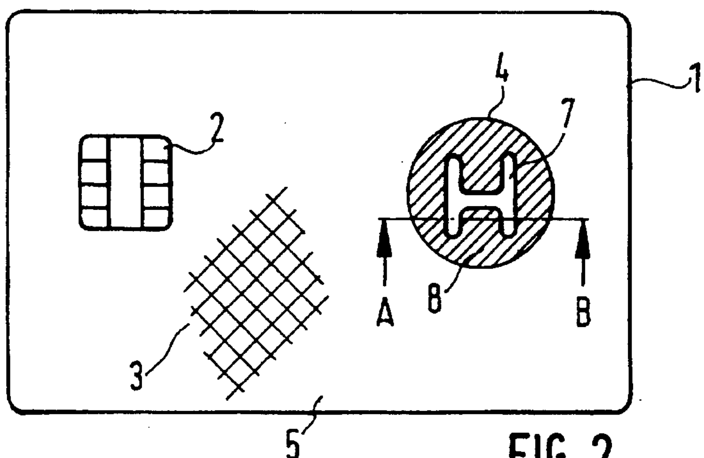


FIG. 2

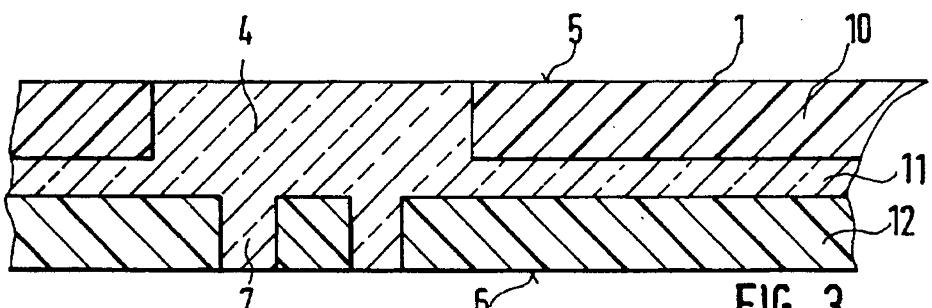


FIG. 3

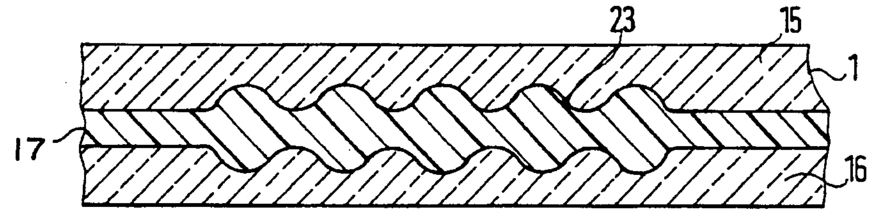


FIG. 4a

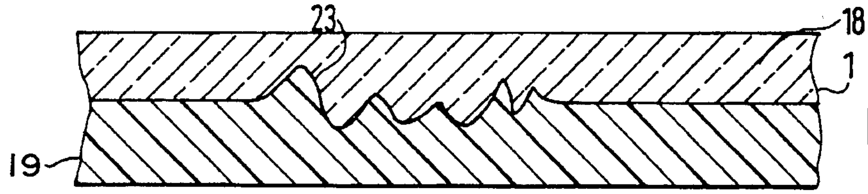


FIG. 4b

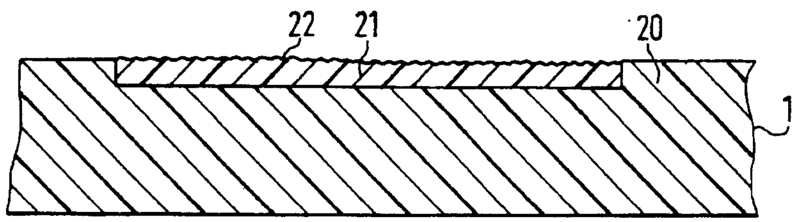


FIG. 5

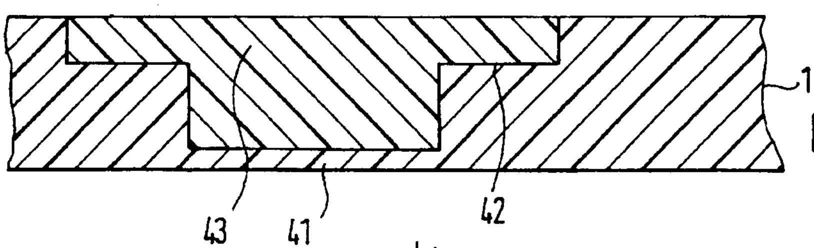


FIG. 6

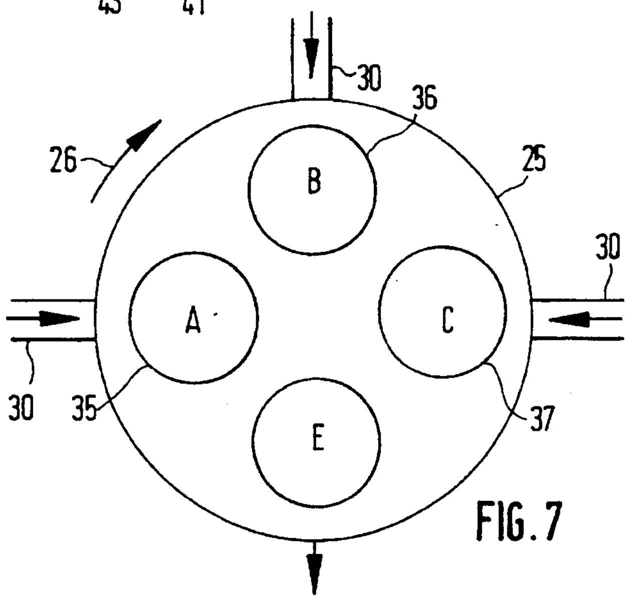


FIG. 7

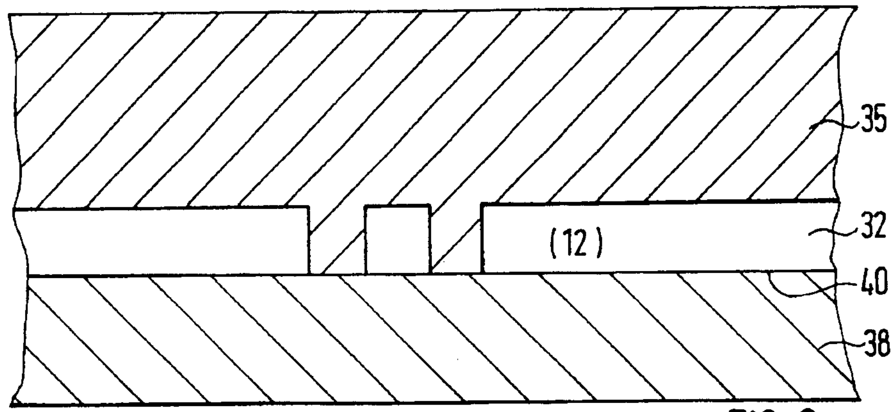


FIG. 8a

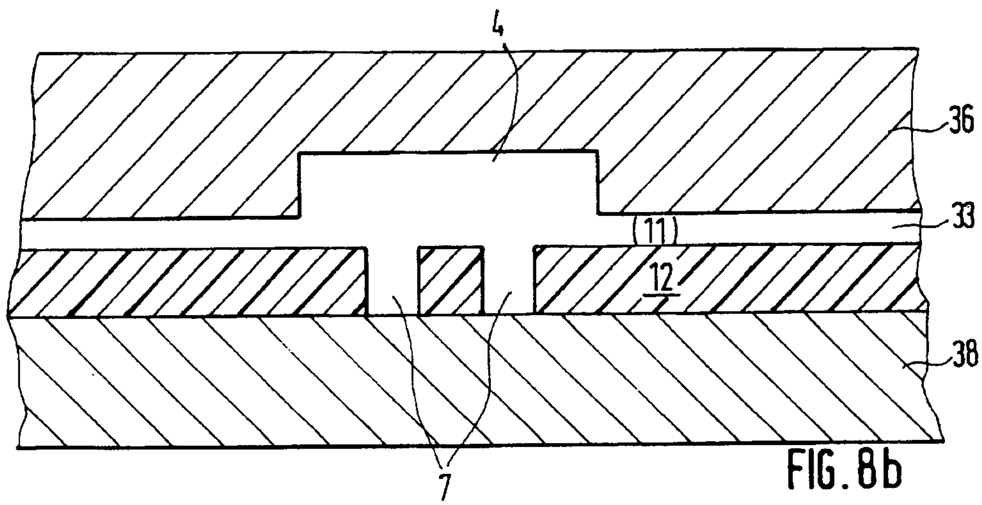


FIG. 8b

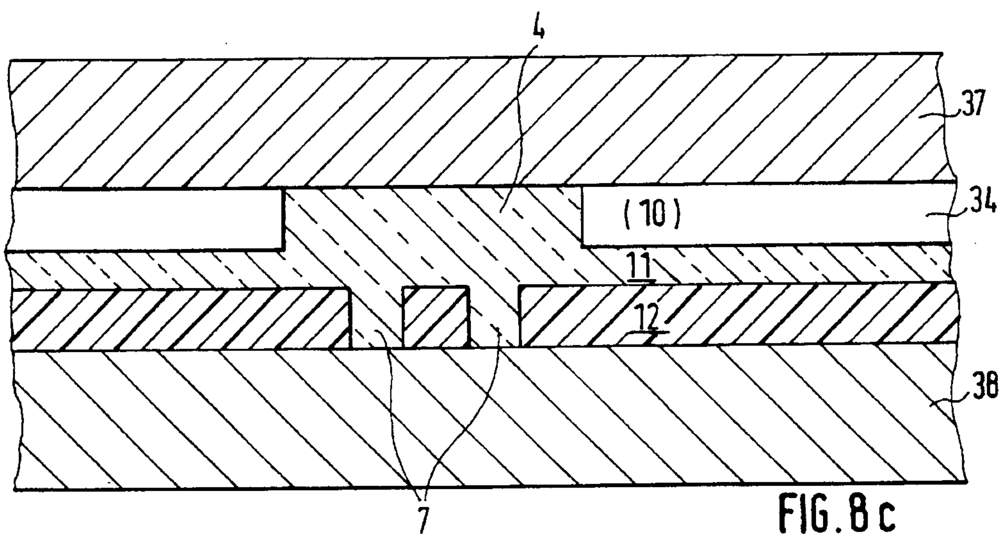


FIG. 8c

IDENTITY CARD AND A METHOD AND APPARATUS FOR PRODUCING IT

This application is a continuation of application Ser. No. 07/992,725, filed Dec. 18, 1992, now abandoned.

The present invention relates to a card produced by injection molding, in particular an identity card, chip card or the like, and to a method and apparatus for producing it.

In recent decades cards have become established in daily life in a great variety of areas. They are in use as identity cards, driver's licenses, access control cards, chip cards, credit cards, check guarantee cards and so on.

In the development of cards a trend has come about in the course of time according to which highest priority is given to their simple and inexpensive production. Cards have therefore passed from the original, extremely high-quality paper inlay card to the so-called all-plastic laminated card, and then to the injection molded card. Such cards are known for example from the publications, DE-C 23 08 876, EP-C 0 101 968, EP-C 0 197 847.

With paper inlay cards the antifalsification techniques known from paper-of-value manufacture were used to produce paper inlays that, embedded between transparent films, convey the esthetic impression of a paper of value while permitting visual and possibly also manual testing of the authenticity features customary in papers of value.

All-plastic laminated cards are, as their name says, constructed completely of plastic layers. The inlay in these cards can be equipped within certain limits with printed patterns equivalent to those in paper inlay cards, but it is either impossible or unreasonable for financial reasons to provide classical authenticity features suitable for human testing.

With injection molded cards, which can be produced extremely inexpensively like customary injection molded parts in injection molding machines, the quality of the printed pattern is again considerably reduced from today's point of view. Real advantages thus result only in the production of chip cards since the injection molding technique permits the card depressions required for embedding the chip modules to be produced in one operation during production of the card body, or even the chip module to be embedded in the card structure during the injection process.

In the further development of production techniques the possibility of human authenticity testing was thus increasingly abandoned in favor of cheaper production methods. With current injection molded cards, if they are chip cards, the electronic security can be increased to almost any degree by using ever more complicated integrated circuits, but the card structure as such is extremely simple and thus fairly unsuitable for strictly visual authenticity testing.

The problem of the invention is therefore to propose a card and a method and apparatus for producing it that take sufficient account not only of the aspect of inexpensive production in high piece numbers but also of the security aspect with respect to visual authenticity testing.

This problem is solved when the card structure has different volume areas containing different plastic components which are formed and disposed in such a way as to be distinguishable from one another visually and possibly also by machine.

The invention exploits the fact that at the current level of injection molding technology a great variety of both plastic components and foreign bodies can be processed in almost any desired arrangement and combination in multi-stage methods. If one utilizes these possibilities to produce a multicomponent card structure one can produce human

features similar to those known from classical paper-of-value protection technology without neglecting the originally desired economizing effect.

It proves to be particularly advantageous that the invention goes on from classical card protection technology while utilizing up-to-date production techniques. Although the inventive card can have a great variety of visually testable card structures it can be readily integrated into common injection molding production methods. Along with the card properties provided for visual authenticity testing, further measures can be provided for facilitating the further processing of the cards or obtaining further production-related economizing effects.

Developments of the invention and further advantages thereof can be found in the embodiment examples described with reference to the drawing, in which:

FIG. **1** shows a conventional chip card from the front,

FIG. **2** shows an inventive multicomponent injection molded card with a visually testable authenticity structure,

FIGS. **3** to **5** show cross-sectional drawings of different variants of the inventive card structure,

FIG. **6** shows a cross-sectional drawing of a structural element for economizing card production further,

FIG. **7** shows a schematic diagram of an apparatus for producing inventive cards,

FIGS. **8*a*** to ***c*** show cross-sectional drawings for schematically illustrating the structure of the injection molding tools for producing the card structure shown in FIG. **3**.

FIG. **1** shows a schematic representation of a conventional chip card **1** with an embedded chip module **2** and a printed pattern **3**. Such cards are currently produced either by the classical laminating technique, i.e. by welding together several plastic layers and embedding the chip module during the laminating operation, or by producing a multi- or one-layer card body and milling in a depression in which the chip module can be inserted. The third and currently cheapest technique is to produce the card body by injection molding, either providing the depression for the chip module in the card body during the injection process or already embedding the chip module itself in the plastic compound during the injection process. Outside the area where the chip module is provided, currently known injection molded cards have no additional features produced by injection molding that permit visual or automatic authenticity testing.

FIG. **2** shows an inventive card body **1** in a simplified representation. This card body can have all the previous elements of customary injection molded cards, i.e. a chip module **2** or a printed pattern **3**. But it furthermore contains at least one injection molding feature **4** that gives the card body a special character. This feature **4** is visually testable in a simple way and producible economically in large piece numbers but very difficult to imitate in single pieces (forgeries).

Injection molding feature **4**, in the present case a letter "H" disposed in a circular area, is a representative example of a company logo, letter or pictorial symbol of any structure. In the present case card body **1** is provided on the front with a white card surface against which circular area **8** stands out.

FIG. **3** shows section A–B from FIG. **2**. Card **1** is accordingly constructed of three layers, whereby layer **10** forming the front is white, back layer **12** is black and the middle layer is transparent. Front layer **10** and back layer **12** each have recesses that are likewise filled with the transparent plastic material of the middle layer. The recess on the front is of circular shape. It thus creates the contour of

injection molding feature **4**. The recesses in back cover layer **12** are in the form of pictorial symbol **7** so that symbol **7** is recognizable as a transparent "H" in black surroundings.

Such a feature **4** can be tested in three steps, namely in transmitted light from the front. In this test one sees a transparent symbol **7** extending throughout the card thickness and embedded in the deeper black background of the card. On the back, symbol **7** is disposed in the all-over black background. Regarding the side edges of the card one likewise readily sees the three-layer structure due to the strongly contrasting layers. Bending tests show whether the card structure and in particular the two card surfaces are of seamless and homogeneous design.

If the security of this card structure is to be further increased a hologram relief can be additionally provided in the surface of the back of the card during card production. This relief can be applied separately by the transfer method or be embossed during the injection process by providing such a relief in the injection mold.

Such a hologram relief placed on side **6** of the card is readily recognizable over the total surface, i.e. both in the black card area and in the area of symbol **7**, when suitably illuminated from the back. Inhomogeneities resulting from the piecing together of various parts of the card (forgery) are particularly easy to detect in this embodiment. From the front of the card only pictorial symbol **7** has holographic effects when sufficiently illuminated in transmitted light.

If inner layer **11** is provided with fluorescent substances the fluorescent effect can likewise be included in the testing of the card.

It is also very easy to clarify the question of whether feature **4** is a homogeneously embedded element. One illuminates the card from the side edges, possibly using a specially provided apparatus, and regards pictorial symbol **4**. Due to the guidance of light within inner layer **11** the pictorial symbol will "glow" in a very characteristic way. If feature **4** was inserted subsequently or put together from different layer elements this prevents the expected light-guiding effects, so that a genuine element **4** also differs from imitations very clearly in this test.

FIGS. **4***a* and **4***b* show a further variant of the inventive card structure. In FIG. **4***a* an opaque inner layer **17** is embedded between two transparent cover films **15** and **16**. The opaque layer has a surface relief **23** on both sides that is recognizable as a relief from each side in incident light. Like an authentic watermark, the relief also appears darker in the thin areas than in the thick relief structures. In transmitted light a reversal of the optical effect can likewise be detected as with an authentic watermark, i.e. in this case the thick relief areas appear dark and the thinner structures light.

In terms of the optical effect the embodiment shown in FIG. **4***b* is very similar, i.e. here too a reversal of the light/dark structures can be detected depending on whether they are regarded in transmitted light or in incident light. However the effect is more powerful through transparent layer **18** than from back layer **19**.

In special embodiments it may suffice to provide only one hologram on the card surface. In this case, as apparent from FIG. **5**, the card area intended for the hologram (that may also extend over the entire card surface) is underlaid with a plastic compound with metallic luster or a very dark, preferably black, colored plastic material. The thickness of layer **21** is of lesser importance. It is only important for the invention that this layer is incorporated by injection molding and that the space of the injection mold adjacent this surface has a holographic relief which is embossed into black or metallescent surface **22**.

Since the described layer structures and layer thicknesses can be produced relatively exactly these effects are very easy to detect by measuring technology if they are suitably dimensioned and designed. One thus not only has the possibility of visual testing but can also add special substances to the individual layers of the card structure and evaluate properties that are largely or completely concealed from visual testing. In this connection reference is made to magnetic effects, electrically conductive effects or luminescent effects in the invisible spectral range.

Departing from the embodiments described in FIGS. **3** to **5**, whereby the inventive principle for producing special optical or measuring effects was described using compatible plastic materials, FIG. **6** shows an embodiment that uses incompatible plastic components for improving production operations.

FIG. **6** shows a section through the chip card area in which a chip module is later to be inserted. This area comprises card body **1** provided with a stepped depression **42**. Bottom area **41** has a wall thickness of about 100 micrometers. After the card blank is completed this area is printed from both sides in separate method steps. A chip module similar to element **43** is then inserted.

When printing cards there was always the problem up to now that area **41** gave way to the pressure of the print roll so that errors in the printed pattern were produced in this area. Furthermore there is the danger of area **41** being damaged by mechanical action so that the card body becomes useless.

The inventive principle provides for injecting incompatible plastic materials into stepped depression **42** in one of the injection molding units. This fills the depression with insert element **43** so that area **41** can be readily printed in subsequent printing operations. When the various printing operations are over the card blank is for example bent over a curved surface to remove element **43**. In this way it is easy to remove the insert element and replace it by a chip module.

The embodiment example described with reference to FIG. **6** is particularly useful for producing injection molded cards that are printed and then equipped with the chip modules in separate operations. This application is recommendable both for single cards and in cases in which multicopy sheets are to be produced by the injection molding technique.

FIG. **7** shows the schematic structure of a rotary table injection molding machine for producing e.g. a card in three separate injection operations (units A, B and C). The fourth unit E is provided for removing the card from the apparatus.

Referring to FIGS. **8***a* to *c*, the mode of functioning of the injection mold can be described as follows.

The injection mold basically comprises two rotary tables, the upper one being rigid and the lower one being rotatable in the direction of arrow **26**. The upper rotary table is also vertically displaceable by means of apparatus elements not shown so as to permit a raising and lowering of this mold part. In the area of the four segments A to E the lower rotary table has depressions corresponding to the particular card shape. Depending on the embodiment the depth of these mold areas can be varied. In the present case it corresponds to the later card thickness.

In the mold parts of the upper rotary table the structures of mold parts **35**, **36** and **37** are provided. These structures are adapted to the particular layer areas **12**, **11** and **10** to be produced.

The different plastic components are injected into the mold via material feed means **30**. After each injection operation the upper rotary table is raised and the lower rotary table turned further by one phase.

As apparent from FIG. **8***a*, layer **12** is injected in mold space **32** in the first unit (unit A). If a hologram relief is also to be produced on the back card surface, surface **40** must be equipped with such a relief. This can be done either by equipping the mold surface with the hologram relief or by inserting relief films that are replaced for each card or after a certain number of injection operations.

After the plastic material which is black in the described example has been injected in unit A the mold is cooled until the plastic compound solidifies. Upper mold part **35** is then raised and lower mold area **38** transported together with layer **12** to unit B. In unit B the mold part required for producing layer **11** is made available. Mold space **33** to be filled in unit B is positioned above layer **12** and in the present case filled with transparent plastic material. During this process both layer **11** extending over the entire card surface and the recesses provided in the area of the injection molding feature are filled with transparent material. After upper mold part **36** is raised and the lower rotary table rotated further the now two-layer card structure **12, 11** passes to unit C. Here the card structure is placed under mold part **37** for as yet lacking layer **10** to be injected in mold space **34**.

After the card material is cooled and solidifies again the upper mold part is raised once again and the rotary table rotated further to pos. E for removal of the card.

It is obvious to the expert that the injection operations in units A, B and C take place at the same time, i.e. after two initial phases a finished card can be removed from unit E with each phase.

It is likewise obvious that one can use not only the card features explained with reference to FIGS. **3**, **4** and **5** but also each feature per se or combinations of these features in one card. In addition one can emboss the depression for chip module **2** as well during the production of these cards. This can be done for example with the aid of a movable die to be pressed into the plastic compound while it is still ductile,

Without departing from the inventive principle it is of course also possible to embed foreign bodies in the card structure as well. These may be for example safeguarding threads or prefabricated inlay areas introduced into the mold, or chip modules that are pressed into the plastic compound in the last working step or placed in a previously produced cavity.

Although the production of the inventive cards has been described with reference to a rotary table injection molding machine the expert will appreciate that this can also be done with other apparatus, for example apparatus in which the individual units A, B, C are disposed in a row and the lower mold parts are clocked past under the units using a kind of endless transport system.

For the cards described in FIGS. **3** to **5** compatible plastic components are used that have the corresponding optical and measuring properties and bond intimately with one another in the particular transitional area when "injected over one another." The expert will know which plastics have this property and will select them together with the particular optical and measuring properties. The same holds for incompatible plastic components that are required for producing removable insert elements **43** (FIG. **6**).

I claim:

1. A method of injection molding a composite plastic identification card body comprising:

in succession, injecting a first plastic resin portion into an injection mold to delimit a first portion only of the card body, said first portion including a recess; permitting the first resin portion to solidify in the mold; then while the first resin portion is in the mold injecting into the mold at least a second plastic resin portion to delimit at least a portion of the remainder of the card body including filling said recess; then permitting the at least second resin portion to solidify in the mold; then removing the composite card body from the mold, wherein one of the plastic resin portions is incompatible with the other, and whereby one solidified resin portion may be separated from the other after the composite card body is removed from the mold to thereby leave a recess in the card body.

2. A method of injection molding a composite plastic identification card body comprising:

in succession, injecting a first plastic resin portion into an injection mold and solidifying said first resin portion to form at least a partial first layer of said card body; then while the first resin portion is in the mold injection into the mold a second plastic resin portion and solidifying said second resin portion to form at least a partial second layer of said card body; then injecting into the mold and solidifying a third plastic resin portion to form a third layer of said card body overlying said second layer; said second layer being molded so as to extend through said first and third layers to the respective outer surfaces of said first and third layers; and then removing the composite card body from the mold.

3. The method as claimed in claim **2**, wherein said second layer is molded so that it extends through said first and third layers at the same location in the card body.

4. The method as claimed in claim **3**, wherein said second resin portion is selected from plastic resins that are transparent when solidified and said first and third plastic resin portions are selected from plastic resins that are not transparent when solidified.

5. The method as claimed in claim **4**, including selecting said first plastic resin portion so that it is opaque when solidified and colored black, and selecting said third plastic resin portion so that it is opaque when solidified and colored white.

6. A method of injection molding a composite plastic identification card body comprising:

in succession, injecting a first plastic resin portion into an injection mold to form a transparent first card layer; permitting the first resin portion to solidify in the mold; then while the first resin portion is in the mold injecting into the mold at least a second plastic resin portion to form an opaque second layer extending over said first layer; then permitting the at least second resin portion to solidify in the mold; and injecting and solidifying a third plastic resin portion using a resin that forms a third card layer that is transparent and overlies said second card layer; said second card layer being molded with varied thickness that is opaque to different degrees and thereby exhibits dark and light areas when observed in incident light, with the dark areas being reversed to light areas and the light areas being reversed to dark areas when observed in transmitted light; and then removing the composite card body from the mold.

* * * * *

US005719746A

United States Patent [19]

Ohbuchi et al.

[11] Patent Number: 5,719,746

[45] Date of Patent: Feb. 17, 1998

[54] IC CARD

[75] Inventors: Jun Ohbuchi; Shigeo Onoda; Katsunori Ochi; Makoto Omori; Tetsuro Washida; Kiyotaka Nishino, all of Tokyo, Japan

[73] Assignee: Mitsubishi Denki Kabushiki Kaisha, Tokyo, Japan

[21] Appl. No.: 587,928

[22] Filed: Jan. 17, 1996

[30] Foreign Application Priority Data

Aug. 18, 1995 [JP] Japan 7-210591

[51] Int. Cl.^{6} H05K 1/14

[52] U.S. Cl. 361/737; 220/402; 206/706; 361/752

[58] Field of Search .... 361/737, 752, 361/820; 206/706–707, 709; 235/488–489, 492; 220/4.02, 4.21; 343/872, 700 MS; 174/52.2, 52.3, 52.4, 52.6

[56] References Cited

U.S. PATENT DOCUMENTS

4,798,946	1/1989	Fujii et al.	361/737
5,461,256	10/1995	Yamada et al.	257/679

Primary Examiner—Michael W. Phillips
Assistant Examiner—Phuong T. Vu

[57] ABSTRACT

An IC card comprises a module with an electric circuit and two panels adhered to each other to cover the module between them. The two panels are adhered with an adhesive with a sufficient adhesion strength and seals the module with no path of air to the outside of the IC card. Airtight sealing of the IC card in realized in various ways. For example, a groove having a varying width is provided in one of the panels for applying an adhesive, while a groove engaging to the groove is provided in the other of the panels. When the two panels are adhered to each other, gas channels may be formed in the groove at portions with narrower widths, while an adhesive in the groove at portions with wider widths fills the gas channels due to viscosity. In another way, a protrusion provided in one of the panels has an edge opposite to a groove provided in the other of the panels. Thus, the groove is kept air-tight. In a different way, an adhesive having a high viscosity at curing temperature is used. In a still different way, all the space inside the IC card is filled, or a sufficient amount of an adhesive is filled in a space between the two panels around a peripheral thereof. In a further way, the panels are adhered in a thermostat. In a still further way, the panels are adhered with melting at a peripheral thereof.

13 Claims, 8 Drawing Sheets

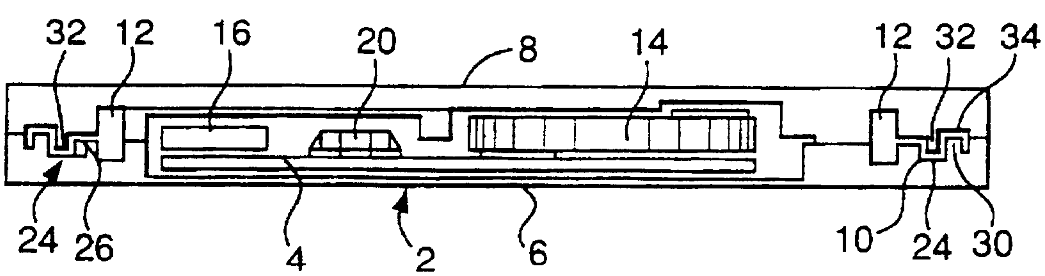


Fig. 1

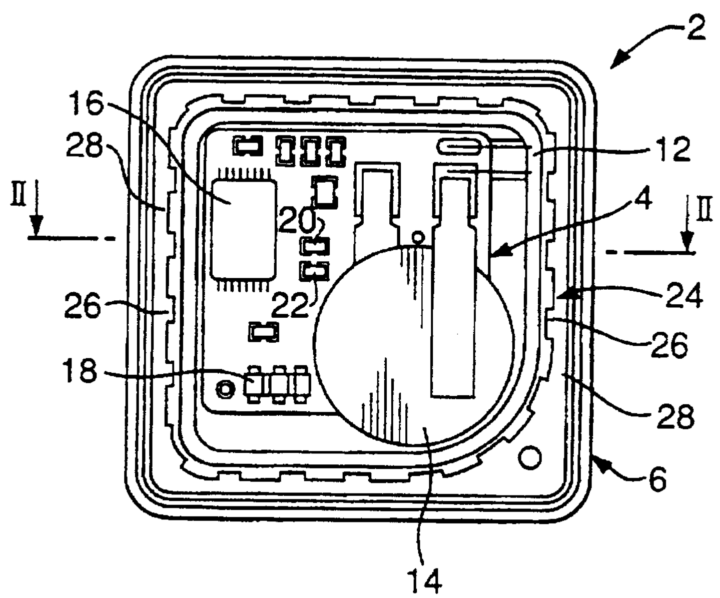

2
16
28
II
20
22
26
18
12
4
II
24
26
28
6
14

Fig. 2

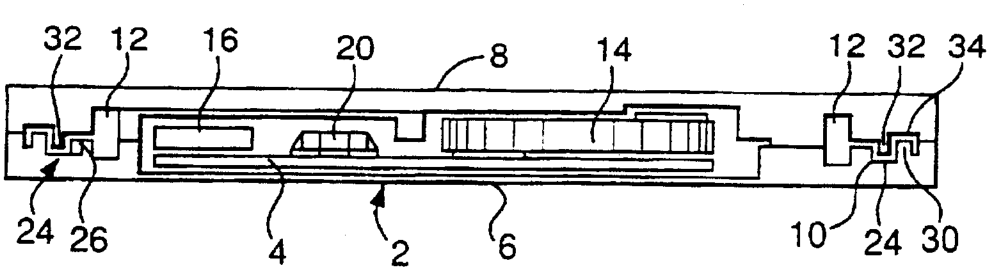

32
12
16
20
8
14
12
32
34
24
26
4
2
6
10
24
30

Fig.3

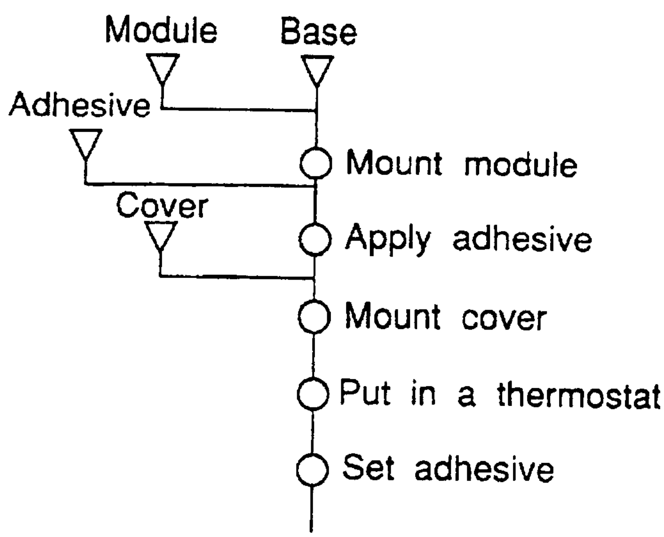

Module
Base
Adhesive
Mount module
Cover
Apply adhesive
Mount cover
Put in a thermostat
Set adhesive

Fig.4

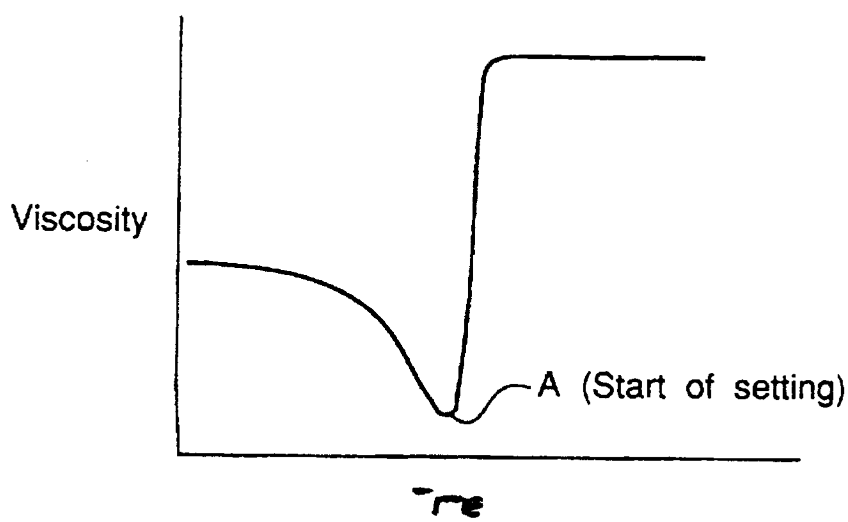

Viscosity
A (Start of setting)

Fig.5

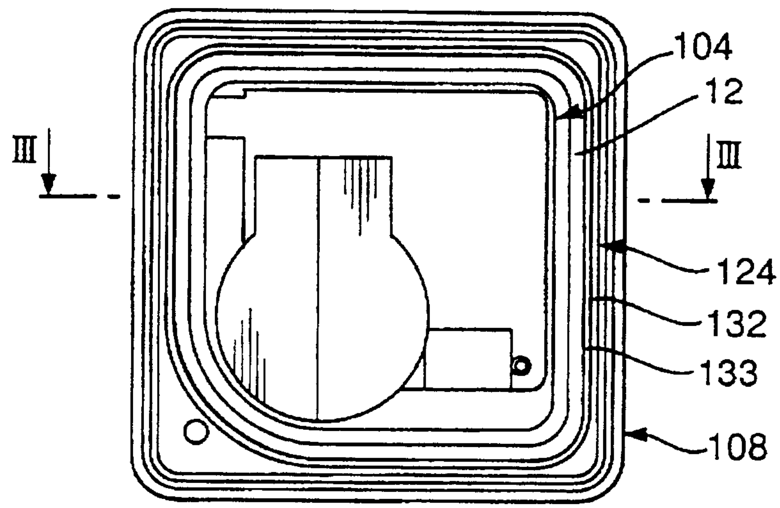


Fig.6

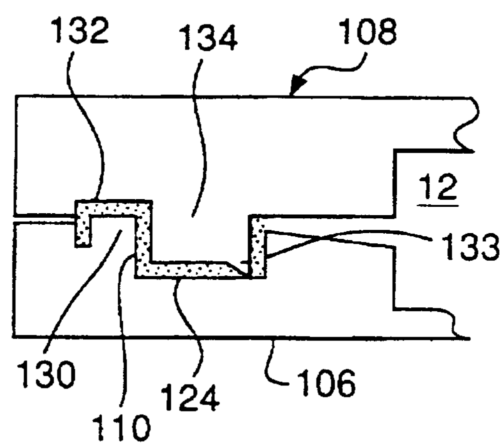


Fig. 7

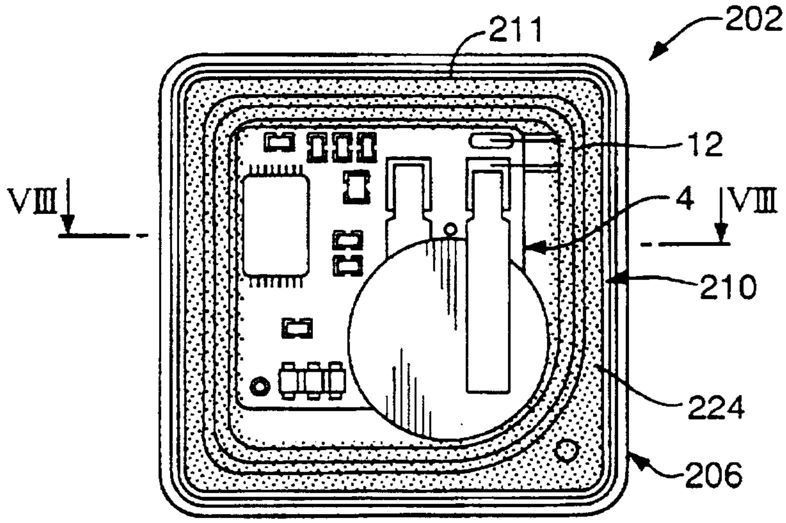

211
202
12
VIII
4
VIII
210
224
206

Fig. 8

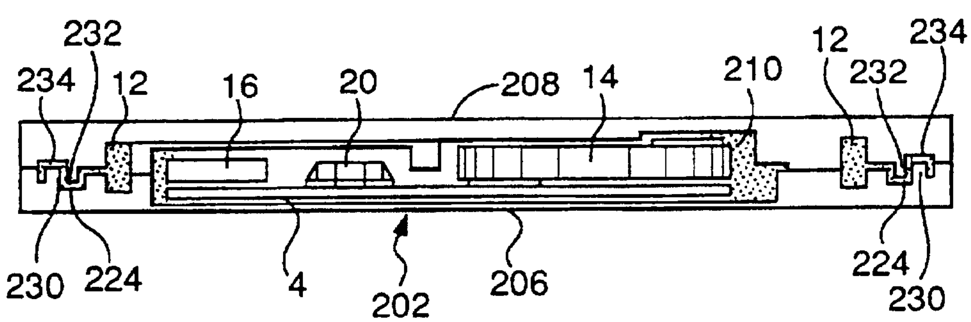

232
234
12
16
20
208
14
210
12
234
232
230
224
4
202
206
224
230

Fig.9

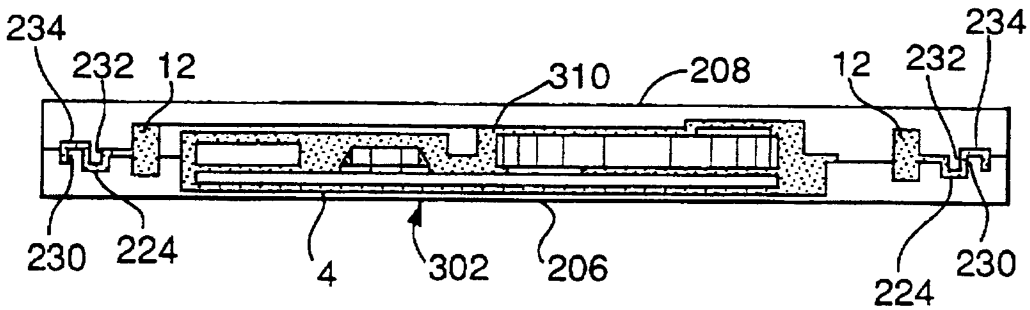

234
232
12
310
208
12
232
234
230
224
4
302
206
224
230

Fig.10

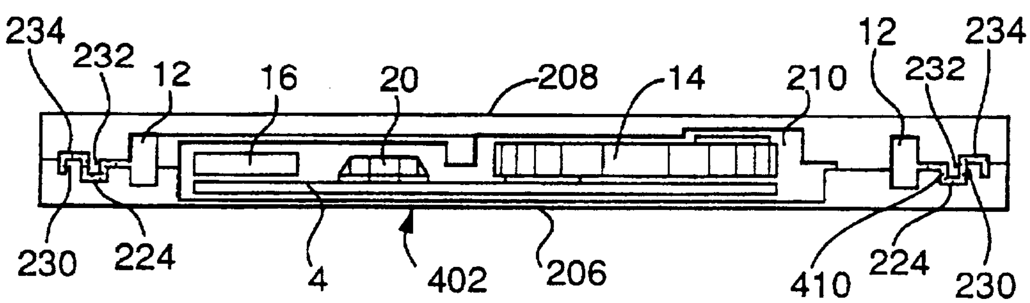

234
232
12
16
20
208
14
210
12
232
234
230
224
4
402
206
410
224
230

Fig. 11

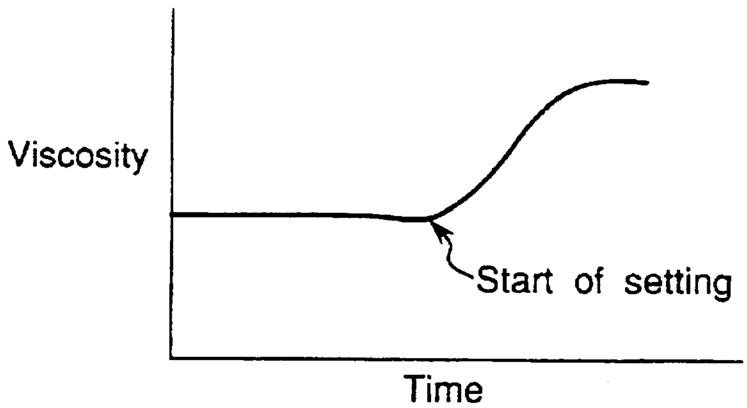
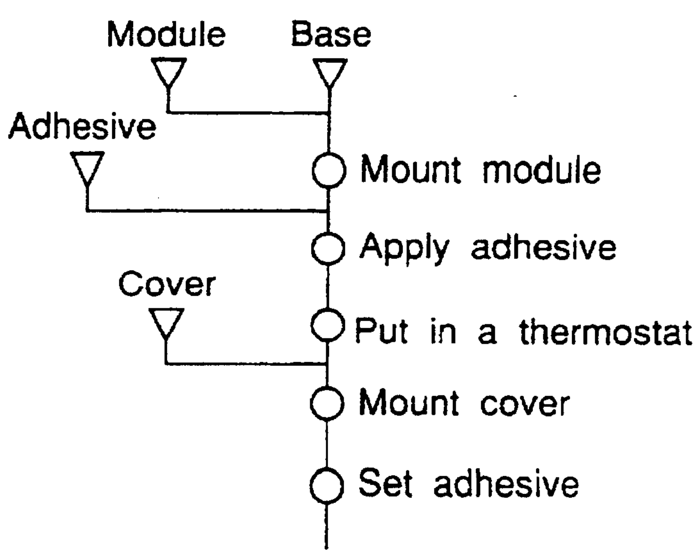

Viscosity
Start of setting
Time

Fig. 12


Module
Base
Adhesive
Mount module
Apply adhesive
Cover
Put in a thermostat
Mount cover
Set adhesive